TECHNICAL BULLETIN No. 89 MARCH, 1929

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UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

U. S. GOVERNMENT PRINTING OFFICE: 1929

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INTRODUCTION

The European red mite (*Paratetranychus pilosus* Can. and Fanz.) has recently come into prominence as an important pest of deciduous fruit trees in North America. It has been particularly abundant in the Pacific Northwest, where it has caused a great deal of damage. This local abundance, and the growing importance of this pest throughout the country, led the Bureau of Entomology to make a thorough biological investigation of the European red mite at the Yakima, Wash., station. At the same time extensive control experiments were made, which have been reported upon in Technical Bulletin No. 25 of the United States Department of Agriculture (*22*).[1] The present bulletin gives only the results of the biological work, which was conducted during 1923, 1924, and 1925.

[1] Italic numbers in parentheses refer to "Literature cited," p. 68.

HISTORY

The European red mite, as its name implies, was first noted in Europe, and it has probably been brought to this country in the same way that many other insect pests have come, that is, on imported nursery stock. The species was first described in 1877–78 as *Tetranychus pilosus* by Canestrini and Fanzago (*3*), who recorded it from Italy. There seem to be few European references to the species. Zacher (*31*), in 1913, erected the genus Paratetranychus, in which he placed the European species *ununguis* Jacobi and *pilosus* Can. and Fanz. In 1915 Trägårdh (*29*) reported that *pilosus* was common in Sweden, and gave a short biological account of it.

The European red mite was first observed in the United States by Ewing (*9*), who found it in Oregon in November, 1911, and reported it as "*Tetranychus mytilaspidis* Riley, the well-known red spider of citrus trees." As will be shown later, there has been much confusion over the identity of *T. "mytilaspidis,"* and *P. pilosus* has often been referred to under that name. Essig (*5*), in 1912, reported that "*mytilaspidis*" occurred on apple, prune, and peach in California, as well as on Citrus, and the senior writer found it on pear at Sacramento, Calif., in 1912.

From 1912 on the European red mite began to appear in various parts of eastern North America. Many of the entomologists reporting it were evidently not familiar with the citrus mite, and they usually identified the species occurring there as *Paratetranychus pilosus*. Caesar (*2*) found this species in Ontario in 1912, and Parrott (*23*) reported it from Geneva, N. Y., in 1915, using the name "*mytilaspidis.*" Frost (*11*) found *pilosus* in Pennsylvania in 1918; Garman (*12*, *13*) reported it from Connecticut in 1920, giving the first extended account of its appearance and habits; and Williams (*30*) mentioned its occurrence in Ohio in 1920, stating that it was very common on apple. Hamilton (*15*) reported it from Maryland in 1921, giving a short biological account of it. In the West, Smith (*28*) mentions it as being common in southern Idaho in 1922. The senior writer has mounted specimens collected at Wenatchee, Wash., in 1916, which were at that time tentatively determined by McGregor as "*mytilaspidis.*" Garman (*14*) has published good descriptions of the various stages and has given the results of certain biological investigations in Connecticut.

The European red mite has also been referred to as the imported red spider and the plum spider mite. Neither of these names is as appropriate as the first one, since it is a mite and not a spider, its original habitat apparently is Europe, and the plum is only one of many food plants.

SYNONYMY

The identity and nomenclature of *Paratetranychus pilosus* (Can. and Fanz.) and of the citrus mite (*P. citri* McG.) have been very confusing to those who have not made a careful study of them. This is due to the unusual superficial similarity of these species, and to a misconception as to what mite Riley (*26*) referred to in his original description of *Penthalodes mytilaspidis*, published in 1885. Banks (*1*), in 1900, concluded that Riley's description referred to the citrus red spider, and the latter went under this name for 16 years,

until McGregor (*17*), working with Riley's type material, showed in 1916 that it was not the same, and gave it the name *Paratetranychus* (*Tetranychus*) *citri*. In the meantime a species of Paratetranychus appeared in this country on deciduous trees and was referred to by some writers as *P. pilosus*. As already mentioned, other writers considered it the same as the citrus mite, and therefore referred to it as "*Tetranychus mytilaspidis*." It was next claimed by Essig (*6*, *7*, *8*) that the deciduous mite and the citrus mite were identical, and he made *citri* a synonym of *pilosus*, owing to the latter being the older name, although McGregor (*18*), in 1919, figured and described anatomical differences which he considered to be of specific value. Recently McGregor and the senior writer made a comparative study of the anatomy, appearance, and biology of the citrus and deciduous species, and have concluded that they are distinct. The results of this study have been published in the Journal of Agricultural Research (*20*).

The synonymy of the European red mite should then stand as follows:

Paratetranychus Pilosus (Can. and Fanz.)

Tetranychus pilosus Can. and Fanz., 1877–78 (*3*).
Tetranychus mytilaspidis (of authors).
Paratetranychus pilosus (Can. and Fanz.) Zacher, 1913 (*31*).

Since there is some doubt and confusion regarding the synonymy of these mites and it is not the purpose of this bulletin to attempt to straighten this out, what may appear to be a more or less arbitrary stand on the matter will have to be taken. For the purposes of this bulletin, then, the European red mite (*P. pilosus* Can. and Fanz.) will be considered to be the mite belonging to the genus Paratetranychus that infests deciduous fruits in both Europe and North America.

DISTRIBUTION

The European red mite, according to European literature, is distributed over continental Europe from Italy to Sweden and Norway and from France to Russia. It does not seem to have been reported from the British Isles.

In North America its distribution is rather general along the Atlantic coast from Nova Scotia to Virginia and west to Ontario, Michigan, and southern Indiana. In the West it is found from British Columbia south to central California and east to southern Idaho and northern Utah. The American distribution is shown more in detail in Figure 1. This mite has not been reported on deciduous plants south of latitude 37° N. This is also true of the European distribution.

FOOD PLANTS

The favorite food plants of the European red mite are the common deciduous fruits, particularly the plum, prune, apple, and pear. It has also been found on the cherry, peach, almond, grape (*32*), raspberry, and plants of the genus Ribes (*32*). Other plants recorded as food plants include the rose, black locust (Robinia), elm, hawthorn, privet, lilac, chestnut, Frangula, Pittosporum (*4*), and pine (*21*). Some of these records, particularly the last two, are probably of accidental occurrences, and the occurrence on Pittosporum

may be that of the citrus mite. At Yakima, Wash., this mite was found occasionally on rose, elm, and black locust (*Robinia pseudoacacia*), and experiments showed that it could maintain itself and reproduce on the locust. Winter eggs were found on the elm and locust.

ECONOMIC IMPORTANCE

The European red mite is important economically as a pest of deciduous fruit trees. The injury caused to these trees is very difficult to determine, as it is not easily measured, and it varies greatly with different varieties of fruits and under different conditions.

The apple, pear, prune, and plum are the most seriously affected by the mites. Cherries are affected to a lesser degree, and peaches and apricots seem to be comparatively free from attack. Since the mites are very unevenly distributed in the orchards of the Pacific

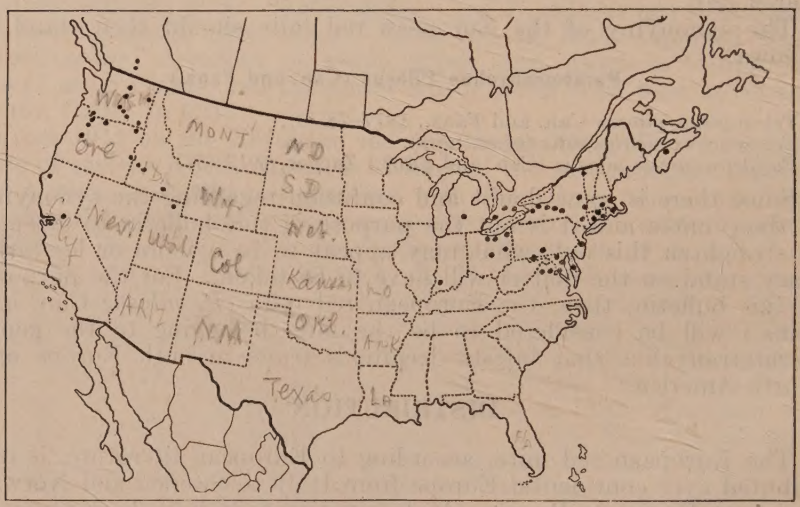


FIGURE 1.—Distribution of the European red mite in North America. Dots represent specific occurrences. The southern boundaries of Utah, Colorado, and Kansas are on latitude 37° N.

Northwest, and since individual orchards usually contain only a few varieties, it has not been possible to obtain very much information on the comparative susceptibility of the different varieties of fruits. Among apples no variety has been observed to be particularly immune. The Rome Beauty seems to be favored by the mites, whereas the Winesap is not so seriously affected. Garman (*14*) states that thin-leaved varieties are most susceptible. No particular difference has been observed in the susceptibility of the major varieties of pears and prunes grown in the Pacific Northwest.

The mites feed by inserting their mouth parts into the leaf cells, the contents of which, including the chlorophyll, are withdrawn. This is well illustrated in Figure 2, which shows a leaf a portion of which was exposed to mite attack while the rest was protected by a felt pad. It is stated by De Ong (*4, p. 50*) that "restoration from this type of injury to a normal condition is rapid if the mites are destroyed before the leaves are badly damaged." If much of the chlorophyll has been withdrawn, however, the plant seems to be

unable to replace it rapidly, and it is never entirely replaced during the life of the leaves. The writers have observed specific instances of chlorophyll removal from Citrus leaves by the allied citrus mite in which the whitened areas remained for over a year.

Apple foliage usually becomes browned or bronzed as a result of mite attacks. In irrigated orchards the leaves seldom drop, the abundance of moisture evidently preventing this. In nonirrigated orchards complete or partial defoliation frequently results from severe mite infestation.

Pears are affected in somewhat the same way as apples. In the Pacific Northwest a browning and drying up of the leaves on the lower parts of the trees, with subsequent dropping, is often manifested in pears, particularly those of the Anjou, Winter Nelis, and Bosc varieties. This trouble occurs during the first period of extremely hot weather in the summer, and it may occur in well-irrigated orchards. It is believed to be due primarily to the inability of the

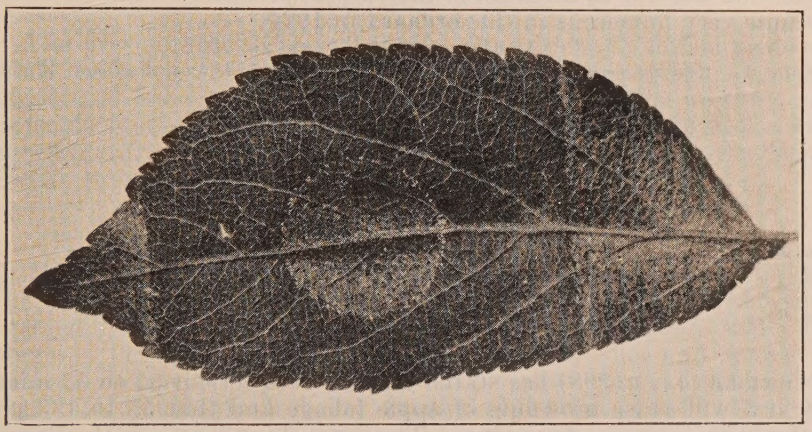


FIGURE 2.—Apple leaf showing effect of feeding by European red mites on the lighter parts, which were exposed to mite attack

tree to supply moisture fast enough during the sudden onset of high temperatures following the usual cooler period, during which heavy vegetative growth often occurs. This defoliation is very likely to be aggravated by a severe infestation of mites, since they remove large quantities of moisture from the leaves.

Prune foliage is also bronzed as a result of mite attacks, and is much more likely to drop than apple foliage, defoliation often occurring in irrigated orchards. This is frequently accompanied by a dropping of some of the fruit.

The trees and fruit are also affected by infestations of mites, but these effects are not so easily seen. The mites do not feed on the fruit itself to any great extent, but the fruit is indirectly affected. De Ong (*4, p. 51*) reports two cases in which prunes from infested (unsprayed) trees were 18 and 44 per cent smaller, respectively, than prunes from noninfested (sprayed) trees in the same orchards. Since the trees manufacture their food supply largely in their leaves, any foliage injury will reduce the vitality of the tree and consequently the size of the fruit, if indeed it does not cause it to drop off. Harvey

and Murneek (*16*) have shown that defoliation early in the season affects the setting of fruit and the formation of fruit buds. Mite injury rarely or never occurs early enough to affect the setting of the current year's crop, but it may come early enough to weaken the fruit buds or even prevent them from forming altogether. It is safe to say that injury from mites is often much more serious than is apparent, although it can not always be mathematically expressed.

The writers have kept records of the increase in the number of mites in one orchard at Yakima, Wash., and these records are given in Table 1. The largest number actually recorded was 1,143 mites on three large Rome Beauty apple leaves, or an average of 381 mites per leaf. This record was made on July 22, 1922.

Table 1 shows that a definite increase occurred in 1923 from June to August. In 1924 the mites were more numerous than in 1923, but the numbers were somewhat reduced during July, and in late August of that year live mites were hard to find on these trees. This reduction was due to the work of the various predacious insects, which became very numerous in this orchard in 1924.

TABLE 1.—*Average number of European red mites per apple leaf, Yakima, Wash., 1923 and 1924*

Date	Number of mites per leaf	Date	Number of mites per leaf
1923		1924	
June 20	10 to 40	May 6	48
July 1	25 to 50	June 27	260
July 12	25 to 85	July 30	200
Aug. 7	25 to 100		
Aug. 13	55 to 117		

Garman (*14, p. 108*) has stated that in Connecticut 12 to 33 mites per leaf will cause browning of apple foliage and that 55 to 133 per leaf will cause severe browning. The same thing is true in the Pacific Northwest, the foliage in the orchard referred to being very noticeably browned by the end of June in both years, and severely browned during July. Recovery from this did not occur in 1924, even though the mites were of little consequence after the middle of August. It is evident from these figures that control measures must be taken during May and June to be effective.

DESCRIPTION OF STAGES

The European red mite deposits eggs, from which are hatched six-legged larvae. These change by molting into eight-legged protonymphs, which in turn become deutonymphs and finally adults.

THE EGG

The egg (fig. 3, A) is lenticular, being flattened at the poles, and it is distinctly grooved. A stalk about as long as the diameter of the egg arises from the center, tapering gradually to the tip, which is somewhat bent or curved. When first deposited, the egg is bright red, but soon changes to a deep orange and shortly before hatching takes on somewhat of the transparency of an empty eggshell. The

empty eggshells are of a whitish transparency. The transverse diameter of 40 summer eggs averaged 0.132 millimeter.

The winter eggs are very similar to the summer eggs, except that they are a deeper, richer red, and somewhat larger. The transverse diameter of 40 winter eggs averaged 0.148 millimeter.

THE LARVA

The larva (fig. 3, B) when first hatched is lemon yellow to light orange in color, but after feeding it becomes darker, changing more or less to a reddish brown, depending on the quantity of chlorophyll it has taken with its food. The cephalothorax and the legs and palpi remain largely semitransparent. The larva does not have the conspicuous whitish spots at the base of the dorsal bristles which occur in the adult. It has only six legs, which readily distinguishes it from the other instars. The length of 10 larvae averaged 0.20 millimeter.

THE PROTONYMPH

The protonymph or second-instar mite (fig. 3, C) differs primarily from the larva in having eight legs instead of six. It is somewhat larger and has a deeper, richer color. The size of the protonymphs depends much upon the length of time elapsing since their transformation from the larval stage, as they increase in size. The length of five protonymphs ranged from 0.20 to 0.25 millimeter.

THE DEUTONYMPH

There is less difference between the deutonymph (fig. 3, D) and the protonymph than between any of the other stages. There is so little difference that it is often difficult to distinguish these two stages. The deutonymph is slightly richer in color and somewhat larger. In the latter part of this stage the sexes can be distinguished, the male deutonymph being smaller and more slender than the female. The length of five deutonymphs was from 0.25 to 0.30 millimeter.

THE ADULT

The adult (fig. 4) was originally described by Canestrini and Fanzago (*3, p. 150*). Their description is as follows:[2]

Corpo di forma globosa, troncato anteriormente in linea retta ed alquanto sporgente ai lati verso l' inserzione delle zampe 3° pajo. Sul dorso vedonsi numerose e lunghe setole, disposte in più serie, dirette in alto e dietro, così che l' animale ha l' aspetto d' istrice; sul margine posteriore dell' addome se ne contano 10, le quali non sono altro che le ultime di ciascuna serie dorsale. Una setola omerale, lunga e curva in dietro. Zampe tozze, ad articoli grossi. Esse sono ricche di setole, tra cui quelle al lato esterno degli articoli sono più lunghe di quelle poste all' interno; quasi in ogni articolo ve ne ha una maggiore, staccantesi ad angolo quasi retto.

Corpo nero: vertice, rostro, palpi e zampe di colore ranciato.

Lunghezza: 0.25 mill.

Patria: Trevigiano.

[2] This may be translated as follows: Body globose, squarely truncated anteriorly and somewhat protruding laterally opposite the insertion of the third pair of legs. Dorsally there are numerous long setae, arranged in many longitudinal rows, giving the creature the appearance of a porcupine; there are 10 of these setae along the posterior margin of the abdomen, which are the last ones of each dorsal row. A humeral seta, long and curved backwards. Legs stocky, swollen at the joints. These bear many setae, of which those on the outer sides of the joints are longer than those on the inner sides; at almost every joint is a larger one, standing nearly at right angles. Body black; vertex, rostrum, palpi, and legs orange colored. Length, 0.25 millimeter. Habitat, Trevigiano.

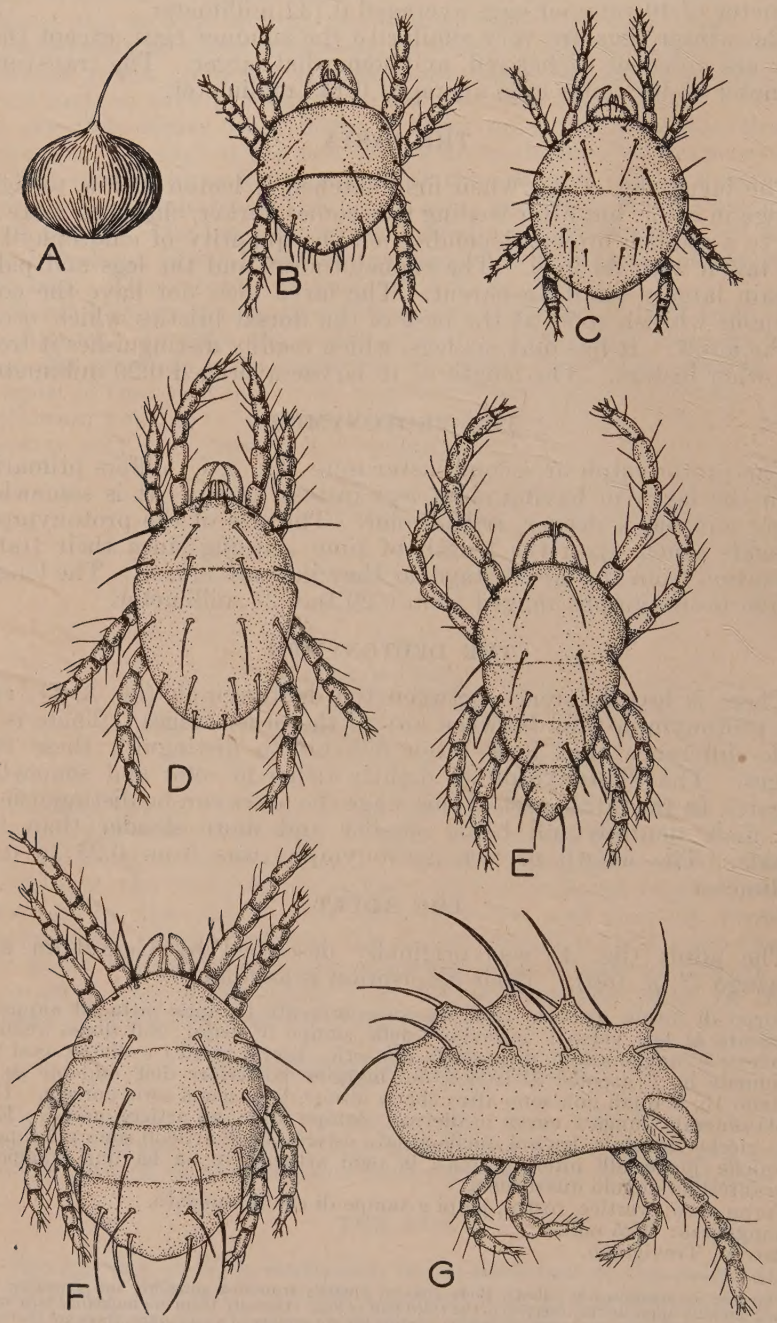


FIGURE 3.—Stages of the European red mite: A, Egg; B, newly hatched larva; C, protonymph D, deutonymph; E, adult male; F, adult female; G, adult female, lateral view. All × 120

Since this description is inadequate for identifying the species, a description of the anatomical features given by McGregor (*18, p. 671*) is presented, together with a description of the color and other gross features by the writers.

FIGURE 4.—European red mites: A, Adults and molted skins; B, adult females. × 15

Dorsal bristles, 26, in four rows, fine-pointed, pilose, and arising from tubercles. Palpal "thumb" bears on its tip a stout spatulate "finger," the thickness of which about equals its length. The usual dorsoterminal digitah, the dorsal "finger" which is tacklike, and the dorsobasal hairs occur on the "thumb."

as well as the lateroventral hair. The tarsus possesses a heavy, sickle-shaped claw which is thickest at mid-point; from this middle point ventrally four appendiculate spurs arise which considerably surpass the claw. The usual four tenent hairs are present. The inner lobe of the penis is club-shaped, thickening considerably posteriorly to form the obtuse basilar lobe; the shaft barely half as long as inner lobe but otherwise similar; hook bent only 45° from the main axis of the penis, sharply acuminate without barb. Collar trachea straight and of even caliber, with spherical, dilated chamber. Mandibular plate narrowed and rounded anteriorly, but not emarginate.

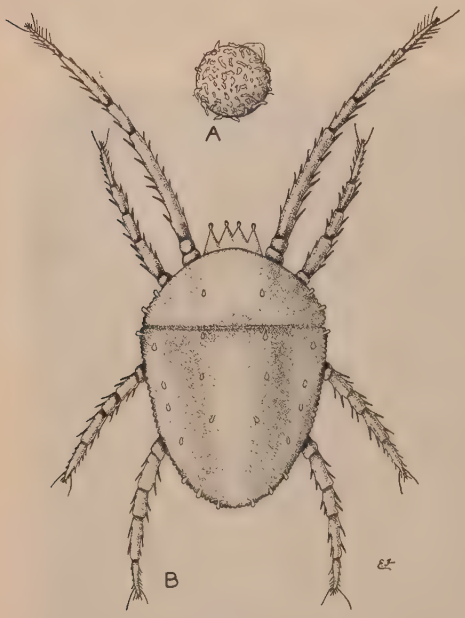
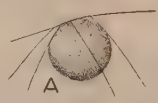


FIGURE 5.—Clover mite (*Bryobia praetiosa*): A, Egg; B, adult. × 64

Female (fig. 3, F, G).—Body robust, decidedly rounded above. When first emerged, the color is bright velvety red, changing in time to a dark brownish red. The tubercles bearing the dorsal bristles are whitish, contrasting strongly with the body color, and the bristles, legs, and palpi are light reddish or fulvous. Eyes red. Length 0.32 to 0.37 millimeter, width 0.23 to 0.26 millimeter.

Male (fig. 3, E).—Smaller than female and more slender. Body ovate, widest at anterior region of abdomen, tapering to a more or less acute point posteriorly. Lighter in color than female. Newly emerged individuals are straw-yellow; those that have fed for a time are greenish, the anterior and posterior ends being fulvous. The color changes to orange with age. Legs and palpi semitransparent. Eyes conspicuous, red. Length 0.27 to 0.30 millimeter.



RELATED SPECIES

In the deciduous-fruit regions two other mites occur commonly which are sometimes confused with the European red mite. One of these is the clover mite or brown mite (*Bryobia praetiosa* Koch). (Fig. 5, B.) This is a common pest of fruit trees and is readily distinguished from the European red mite in the young and adult stages by the fact that it is decidedly flattened dorsally, has very much longer legs, and is dull reddish or greenish. The eggs are similar to those of *P. pilosus*, the winter eggs in particular often being almost indistinguishable. They are slightly larger, however, are more nearly spherical, and lack the stalk and the striations. (Fig.5, A.)

FIGURE 6.—Common red spider (*Tetranychus telarius*): A, Egg; B, adult. × 64

The work of the common red spider or two-spotted mite (*Tetranychus telarius* L.) (fig. 6, B) is sometimes taken for that of the European red mite. This mite, however, is more gregarious in habit, and spins

a great deal of webbing, in which the almost colorless eggs (fig. 6, A) are suspended, and which offers some protection for the greenish or yellowish young and adults. The adults are somewhat flatter and more elongated than those of *P. pilosus*, and usually have two conspicuous dark spots on the dorsum.

While all three of these species sometimes occur on the same trees, usually one of them is dominant, and often only one of the species can be found in a tree or in a whole orchard. When the European red mite is very abundant the other species are rarely found in any numbers. If the common red spider gets a start, the European red mite seems to be unable to maintain itself. This is due to the fact that it can not run about through the webbing spun by the other species, but gets tangled up in it and consequently dies.

The citrus mite (*Paratetranychus citri* McG.) is very similar to the European red mite in appearance, as already noted, but it lives on different plants for the most part, and has a much brighter red color. The tubercles are concolorous with the body, and the egg is supported by guy fibrils radiating from the top of the stalk, which is not the case with *pilosus*. There are also certain anatomical differences.

Paratetranychus ilicis McG. also appears to be similar to *pilosus*, although the writers have not had specimens for comparison. It is apparently confined to the holly.

HABITS

WINTER EGGS

The European red mite passes the winter in the egg stage. The winter eggs may be found on the smaller branches and twigs of the trees (fig. 7), being very much more numerous on the lower sides than above. They are most often deposited about the forks of two branches and in other roughened places, and when the infestation is severe they may be found also in the calyx end of apples. (Fig. 8.) These eggs are bright red, and frequently they are so numerous that they give the branches a reddish appearance. At other times a close examination will show that most of the eggs are transparent and empty. This is usually due to the depredations of some of the insect enemies of the mites which have fed on the eggs.

Trägårdh (*29*) states that the winter eggs hatch early in May in Sweden, and observers in the Eastern States have reported them as hatching in late April and early May. In the Pacific Northwest they hatch about the middle of April, at the time the new leaves are appearing, and, on apples, just before the blossoms open. In 1923, at Yakima, Wash., the eggs were hatching from April 14 to 24, in 1924 from April 10 to 20, and in 1925 from April 10 to 17. The eggshell splits around its equator for most of its circumference (fig. 9), a small portion being left as a hinge. The upper half, or lid, is lifted by the larva, which crawls out, the lid usually springing back to its original position. The hatching of all the winter eggs is usually completed within a week or 10 days. Some observations were made in April, 1925, to determine if there was any difference in the time of hatching on pear and apple. It was found that eggs were hatching at the same time on both pear and apple and that a considerable daily fluctuation occurred in the number hatching, owing to variations in the temperature.

IMMATURE STAGES

The small, bright-red or orange larvae swarm to the young leaves and at once begin feeding. In some cases they may travel several

FIGURE 7.—Winter eggs of the European red mite

inches or even feet before beginning to feed. They crowd down among the unfolding leaves and are not very conspicuous. After a period of feeding, during which the larva moves about to some

extent, it settles down, usually on the under side of the leaf near a vein or midrib, and remains quiescent for a time. The quiescent period lasts about as long as the feeding period. The mite remains perfectly motionless and apparently takes no food. After a time the skin becomes smooth and glossy in appearance and finally turns pearly white, indicating that it has loosened from the new skin underneath. Within a few hours it splits transversely across the dorsum, between the second and third pairs of legs, and the protonymph, which has eight legs instead of six, pushes its way out. The

FIGURE 8.—Winter eggs of the European red mite in calyx end of apple. × 12

molted skins usually remain adhering to the leaf, and in severe infestations these and the eggshells may be numerous enough to give the leaf a silvery appearance. (Fig. 10.)

In the protonymphal stage the feeding and quiescent periods are repeated, each being somewhat shorter than the corresponding period in the larval stage, and the creature molts and becomes a deutonymph. The sex of the deutonymph can be told after it has fed for a time, the females becoming larger and more globose than the males. The duration of this stage is slightly longer than that of the larval or the protonymphal stage. The males complete each of these stages in a

fraction of a day less than the females, the total for the immature stages averaging eight days for the males and nine days for the females.

ADULT EMERGENCE AND COPULATION

Since the male becomes adult first, it runs about over the leaves until it finds a quiescent female deutonymph. It then settles down beside the deutonymph to await the emergence of the female. As soon as the nymphal skin of the latter splits across the back the male begins working at the posterior half of it with his fore legs and mouth parts. The female arches her back and in a few minutes her posterior legs are freed. She then backs out of the anterior half of the old skin, and copulation takes place immediately, sometimes even occurring before the female has had time to free herself entirely from the nymphal skin. The male crawls under the female from the rear, the latter elevating the tip of her abdomen. The male clasps his front legs about her abdomen and his second pair of legs about her hind legs, and then curves the end of his abdomen upward and forward until it meets the end of the female's abdomen. The pair remain in this position for 10 or 15 minutes. Parthenogenesis also occurs. A discussion of this will be found on page 52.

FEEDING

The young mites feed mostly on the lower surface of the leaf, since the feeding periods are relatively short and the periods of

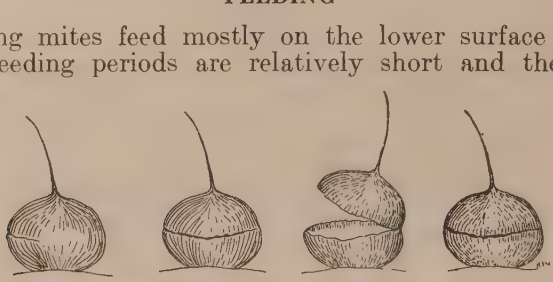


FIGURE 9.—Stages in the hatching of the egg of the European red mite. × 100

quiescence are usually passed on the lower surface, where there is more protection. Those found on the upper surface are usually in the depressions of the veins. The adult mites, however, feed indiscriminately on both surfaces. Observations made on mites feeding on apple (Rome Beauty) foliage in warm, sunny weather showed that about three-fourths of the adults were feeding on the upper surface of the leaves. In cloudy or rainy weather most of the adults are found on the lower surface.

EFFECT OF WEATHER

Although the mites are most active during warm weather, their activity continues at lower temperatures than is the case with many insects. In one case a female mite was seen to deposit an egg at 8 a. m., when the temperature was 57° F., the minimum during the night having been 49°. In another instance copulation took place at 8 a. m., when the temperature was only 50°, the previous minimum having been 42°. Extremely hot weather seems to hinder the development of the mites. From June 30 to July 3, 1924, the weather was extremely warm, and maximum temperatures of 104°, 108°, 104°, and

192°, respectively, were recorded in the rearing shelter. These high temperatures caused a higher mortality among the mites under observation than occurred at other times.

Very little webbing is spun by the mites, but they are able to cling tenaciously to the leaf surfaces, and are not so easily washed off by rains or heavy sprays as is the common red spider. The webbing of the latter species is very easily washed off, and the mites and their eggs are carried with it.

FIGURE 10.—Molted skins and empty eggshells of the European red mite on plum leaf

SUMMER EGG DEPOSITION AND HATCHING

The female mites begin to deposit eggs within a day or two after emerging, in hot weather, whereas in cooler weather they may begin several days or a week later. Eggs are deposited on both surfaces of the leaves in about equal numbers. Counts of 755 eggs deposited on six Italian prune leaves showed that 358, or 47.4 per cent, were on the upper surface, and 397, or 52.6 per cent, were on the lower surface. These eggs are placed most commonly along the midribs and veins and near the edges of the leaves. Hatching occurs in the same manner as with the winter eggs.

NUMBER OF GENERATIONS

The number of generations of the European red mite occurring annually varies with the climate and season. Trägårdh (*29*) reports that four generations occur in Sweden, and Garman (*14*) suggests that there are probably six in Connecticut. In 1923, at Yakima, Wash., the temperature was below normal during April, May, and June, and slightly above normal during July, August, and September. Six complete generations of the mites occurred, and partial seventh and eighth generations. Some adults of the sixth and seventh generations deposited winter eggs, while others deposited summer eggs. No individuals of the eighth generation matured.

In 1924 the average temperature in May was 6° above normal, and that in June was slightly above normal. Although the temperatures were practically normal for the rest of the season, the high temperatures during May and June gave the mites an earlier start, and the sixth generation of 1924 began five days earlier than the fifth generation of 1923, as is shown in Figure 11. There were practically seven complete generations; only a few adults of the sixth generation deposited winter eggs, and several individuals of the eighth generation matured.

On account of the relatively high mortality incidental to handling the mites, it was difficult to carry the progeny of any specific first-brood individual through all the succeeding generations of the season. However, this was accomplished in several instances in 1924, and Table 2 gives a record of these rearings, showing that there were actually eight successive generations in that season. In order to avoid complicating the table, only the dates of hatching for the various broods are given, together with the interval in days between these dates. This interval was not always the minimum, since some of the individuals emerged from other than the first eggs deposited.

TABLE 2.—*Record of progeny of first-brood European red mites reared through succeeding generations, Yakima, Wash., 1924*

No.	First brood, date of hatching	Interval (days)	Second brood, date of hatching	Interval (days)	Third brood, date of hatching	Interval (days)	Fourth brood, date of hatching	Interval (days)	Fifth brood, date of hatching	Interval (days)	Sixth brood, date of hatching	Interval (days)	Seventh brood, date of hatching	Interval (days)	Eighth brood date of hatching
1	Apr. 16	27	May 13	18	May 31	20	June 20	16	July 6	22	July 28	33	Aug. 30	--	
2	---do----	30	May 16	18	June 3	22	June 25	17	July 12	19	July 31	20	Aug. 20	19	Sept. 8
3	---do----	30	---do----	18	---do----	22	---do----	17	---do----	21	Aug. 2	20	Aug. 22	24	Sept. 15
4	Apr. 22	24	---do----	23	June 8	23	July 1	25	July 26	18	Aug. 13	23	Sept. 5	--	

OVERLAPPING OF GENERATIONS

Figure 11 shows graphically for 1923 and 1924 the approximate duration of each generation from the hatching of the first eggs to the death of the last adults. In 1923, owing to the cool spring, which made development rather slow, there was practically no time during the season when there was more than the usual overlapping of the last part of one brood with the first part of the next. Beginning about June 10 there were two broods present for the rest of the season.

In 1924 the abnormally warm weather in May and early June hastened the development of the early broods, with the result that

two broods were present continuously after June 1, and after June 20 there were three broods practically all the time. As a result of this the infestation of mites was much more severe in 1924 than in 1923. As Table 1 shows, the infestation on June 27, 1924, was more than three times as great as it was on July 12, 1923, these two dates occurring approximately 10 days after the beginning of the fourth brood in each case.

DEPOSITION OF WINTER EGGS

Although it has been shown that the winter eggs of the European red mite hatch within a comparatively few days, they are deposited over a rather long period. Deposition of these eggs begins about the middle of August in the Pacific Northwest, and continues until cold weather kills the mites or causes the leaves to drop. In 1925 adult mites were still present on the few remaining apple leaves on Novem-

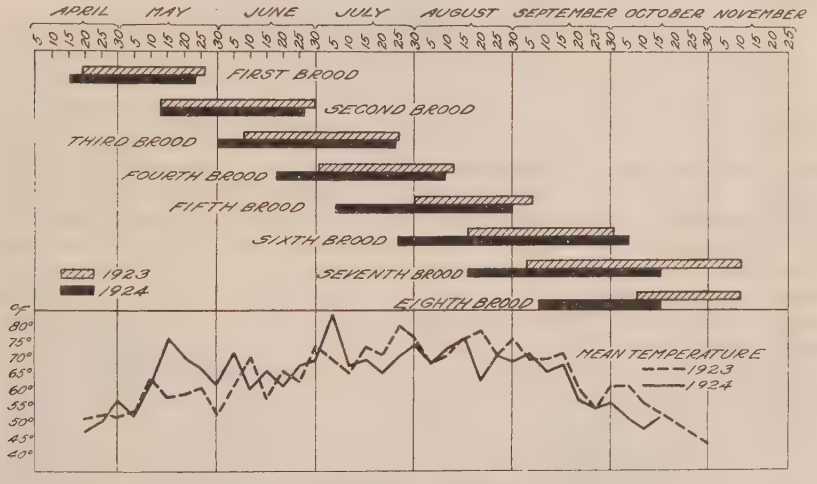


FIGURE 11.—Seasonal history of the European red mite at Yakima, Wash., 1923 and 1924

ber 17. Winter eggs may thus be deposited over a period of three months. Individual females of the sixth, seventh, and eighth broods may deposit these eggs. It has been difficult to distinguish winter eggs from summer eggs in the rearing cells, but it was found that practically no eggs hatched that were deposited by certain females of these broods. This is taken as an indication that these were winter eggs, and that practically all of the eggs deposited by any female were either winter eggs or summer eggs.

DISPERSAL

The winter eggs are present on the twigs for about six months, and, being inconspicuous unless present in large numbers, easily escape detection and are often carried to new localities on nursery stock. The winter eggs deposited about the calyxes of apples are also a possible means of distribution, but the chances of starting new infestations from this source would be extremely small.

During the growing season the mites are very easily transported from one orchard to another on the clothing of men working in the

orchards and on vehicles and farm machinery. They are also probably blown considerable distances by hard winds, and they may be transported by irrigation water. It is conceivable, too, that they could be carried on birds' feet in the same manner as the young of the San Jose scale are carried.

SEASONAL HISTORY

METHODS EMPLOYED IN THE SEASONAL-HISTORY STUDIES

Detailed seasonal-history studies of mites have not been recorded to any great extent. Ewing (*10*) and McGregor (*19*) have made some studies of this character with the common red spider (*Tetranychus telarius* L.), and Garman (*14*) has made a few observations on the European red mite in Connecticut. The lack of extensive biological records is probably due to the apparent difficulty and tediousness involved in making them.

In the biological studies at Yakima, Wash., field records were made at various times, but owing to the overlapping of broods it was evident that laboratory studies were very desirable. It was believed that detailed records could be obtained just as records have been made of the life history of the codling moth and other insects, and it turned out that these records were not so difficult to obtain as might be supposed. The rearing method suggested by McGregor (*19, p. 22*) looked promising, and this method, which consists of rearing mites in individual cells on the leaves, was employed. Since McGregor described the apparatus only briefly in his bulletin, and several modifications have been made to suit the conditions met with, a detailed description of the apparatus and methods employed in this work is given here.

The rearing cell was made of ¼-inch felt, white being the most satisfactory color, as the mites and eggs are more easily seen on it than on darker colors. This felt was cut into squares measuring approximately 1½ inches, and a round hole was punched in the center with a half-inch leather punch. Squares of celluloid were also cut to the same size and punched in the same manner. One of these was glued to each square of felt, and a bit of paper bearing a number was inserted under the edge of the celluloid. A similar square of celluloid, but unpunched, was also used with each cell. These cells were attached to individual leaves on trees growing in the laboratory yard. The cell was placed on the leaf, with the punched celluloid above, the unpunched square of celluloid was placed below the leaf, and the whole cell was then clipped together with paper clips. (Fig. 12.) These clips were bent with pliers so that they could be clipped over the thick cells. In this way a small circle of leaf was exposed in the felt cell, and it was found that even with daily handling the leaves usually remained on the tree throughout the period of observation. Occasionally a leaf turned yellow and dropped, in which case the mites were transferred to another cell.

At first an attempt was made to provide a cover for the cell by putting a narrow ring of sticky material about the opening and placing a cover glass on it, but this was tedious and unsatisfactory. It was necessary to remove the cover glass for each observation, and the condensation of moisture became too great within the cell. It

was found that the mites could be kept within bounds simply by the ring of sticky material without the cover glass. The felt itself also deterred the mites from wandering. Occasional mites got caught in the sticky material, but the losses from this cause were few.

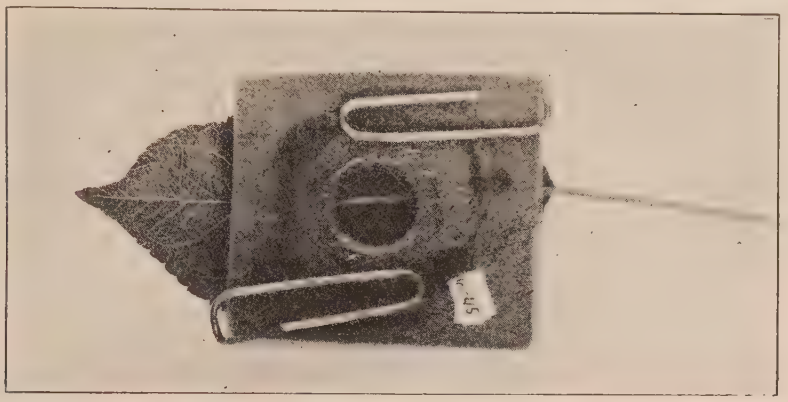


FIGURE 12.—Rearing cell used in biological studies of the European red mite at Yakima, Wash.

The sticky material also prevented predacious enemies and other mites from entering the cells.

The trees used in the seasonal-history studies were young apple and pear trees that were growing in the laboratory yard. (Fig. 13.) A

FIGURE 13.—Rearing shelters used in life-history studies of the European red mite at Yakima, Wash.

frame was erected on the south and part of the east and west sides of these trees, and this was covered with sheeting. This was necessary in order to break the wind, which otherwise would have whipped the cells off the trees, and to prevent the direct sunlight from striking the cells, as it was found that the section of leaf in the cell very soon

burned brown if exposed to the hot sun. The north side and the top were left entirely open, and openings a foot wide were left between the cloth and the ground for ventilation. Temperatures within the shelter were comparable to those outside, as recorded by thermographs.

The mites were placed in the cells by means of fine needles. A fine insect pin was sharpened on an oilstone, the pointed end bent at right angles for about an eighth of an inch, the head removed, and this end thrust into a cork of convenient size. The writers used this needle in preference to a camel's-hair brush, though the latter may be used.

In order to get definite individual records, newly emerged mites were placed in the cells, one individual to a cell. Approximately 100 cells were used for each brood. Observations were made daily,

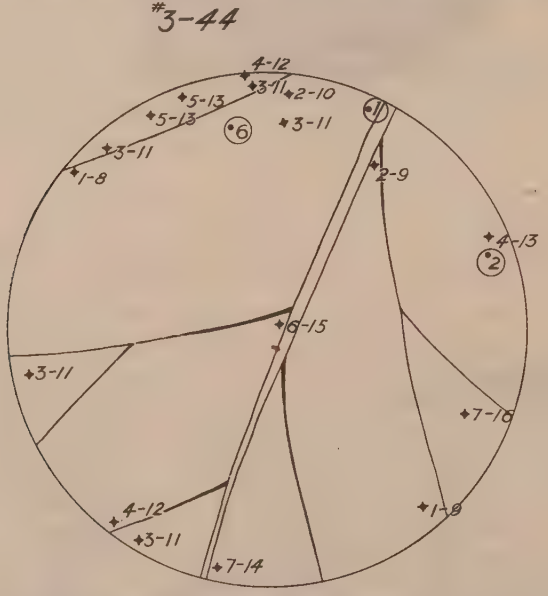


FIGURE 14.—Diagram used in recording incubation period of eggs of the European red mite at Yakima, Wash. Crossed dots represent eggs that hatched, with day of deposition and day of hatching separated by a dash; dots in circles represent eggs that failed to hatch, with day of deposition

usually early in the morning, especially in hot weather, and a record was made of the quiescent periods and of the molts. When a mite became adult, its sex was recorded. If it was a female, it was allowed to remain in the cell, and a record of the oviposition was obtained. If the mite was a male, it was either transferred to a cell containing a newly emerged female, or was left in the original cell by itself, a longevity record being made in either case.

An enlarged diagram was made of each cell, the principal veins being sketched in, and as the eggs were deposited their positions were marked on this diagram, together with the date of deposition. (Fig. 14.) The date of hatching was subsequently recorded, and in this way it was possible to get accurate records of the incubation period, as well as of the total number of eggs deposited and the percentage hatching. The young were usually removed from the cells as they

hatched, whether or not they were used in further work. All observations were made with a binocular microscope having a small vulcanite fork for a stand. This microscope was light enough to be held in one hand, the cell being held in the other while the observation was made. The No. 2 oculars and the a_0 objectives were used.

FIELD STUDIES

Observations on the condition of the mites and the relative abundance of the various stages were made at different times in orchards at Yakima, Wash., as a check on the laboratory studies.

In 1923 hatching of the winter eggs was observed in some numbers in the orchards on April 16 to 19, and it was practically over by the 23d. On April 25 many of the nymphs were ready for the second molt. On May 2 a survey was made which showed that there were no larvae, and that approximately 23 per cent of the mites were protonymphs, 48 per cent were deutonymphs, and 29 per cent were adults. A few second-brood eggs were also observed. On May 16 many summer eggs were found, but few adults were present; a few of the eggs were hatching. On May 18 a count was made, and 9 adults, 360 eggs, and 10 young were found.

In 1924 the winter eggs were hatching April 10 to 19. On May 2 a few second-brood eggs were observed, the first brood of mites being mostly adult. On June 1 to 4 observations showed practically no mites except adults of the second generation. There were also many third-brood eggs and an occasional newly hatched larva.

In 1925 the winter eggs began hatching April 10 and continued hatching until about April 18. By April 28 most of the mites were adults or quiescent deutonymphs, and on April 29 a few second-brood eggs were found.

LABORATORY STUDIES

Detailed seasonal-history studies of the European red mite were conducted during the seasons of 1923 and 1924. The studies in 1923 were not so complete as in 1924, and detailed results are given in this bulletin only for 1924. Summaries of the more important life phases for both 1923 and 1924 are given on page 51 and in Tables 56 and 57. In these tables a generation is considered as beginning with the egg stage and ending with the adult stage.

THE FIRST GENERATION

HATCHING OF WINTER EGGS

In 1923 several twigs bearing winter eggs of the European red mite were examined daily, and the number of eggs hatching was recorded. Most of the eggs hatched April 16 to 19, inclusive, although the total period of hatching ranged from April 14 to April 23, as shown in Table 3.

TABLE 3.—*Hatching of winter eggs of the European red mite, Yakima, Wash., 1923*

Date	Number of eggs hatched	Date	Number of eggs hatched
Apr. 14	1	Apr. 19	31
Apr. 15	3	Apr. 20	11
Apr. 16	19	Apr. 21	8
Apr. 17	47	Apr. 22	4
Apr. 18	33	Apr. 23	2

IMMATURE STAGES OF THE FIRST BROOD

LENGTH OF THE LARVAL PERIOD

The length of the larval period of 108 individuals of the first brood is given in Table 4. It averages 4.99 days, the maximum being 8 days, and the minimum 3 days.

TABLE 4.—*Length of larval period of European red mites of the first brood, Yakima, Wash., 1924*

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	27	70	2.59	4	2	60	2.22	4	1	130	4.81	6	3
Female	50	144	2.88	4	2	109	2.18	4	1	253	5.06	8	3
Both sexes	108	294	2.72	4	1	245	2.27	4	1	539	4.99	8	3

LENGTH OF THE NYMPHAL PERIOD

The length of the nymphal period of the first brood, including the protonymph and deutonymph stages, is shown in Table 5. For 77 individuals the average length of this period was 7.45 days, the maximum 10, and the minimum 5.

TABLE 5.—*Length of nymphal period of European red mites of the first brood, Yakima, Wash., 1924*

PROTONYMPH

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	25	34	1.36	3	1	41	1.64	4	1	75	3.00	5	2
Female	52	83	1.60	3	1	92	1.77	4	1	175	3.37	6	2
Both sexes	77	117	1.52	3	1	133	1.73	4	1	250	3.25	6	2

DEUTONYMPH

Male	25	34	1.36	3	1	64	2.56	4	2	98	3.92	6	3
Female	52	94	1.81	3	1	132	2.54	4	1	226	4.35	6	3
Both sexes	77	128	1.66	3	1	196	2.55	4	1	324	4.21	6	3

COMBINED TOTAL

Male	25	173	6.92	10	5
Female	52	401	7.71	10	6
Both sexes	77	574	7.45	10	5

ADULTS OF THE FIRST BROOD

OVIPOSITION

Oviposition records of adults of the first brood given in Table 6 show that there was an average of 2.28 days before oviposition, 9.94 days of oviposition, and 10.97 days from emergence to last oviposition. An average of 26.03 eggs was deposited by each female.

TABLE 6.—*Oviposition by females of the first brood of the European red mite, Yakima, Wash., 1924*

Days	Number of days—			Number of eggs deposited by 33 individuals
	Before oviposition (47 individuals)	Of oviposition (33 individuals)	From emergence to last oviposition (33 individuals)	
Total	107	328	362	859
Average	2.28	9.94	10.97	26.03
Maximum	5	22	23	83
Minimum	1	3	4	10

LENGTH OF LIFE OF ADULTS

Table 7 shows that males of the first brood lived 8.36 days, on the average, and females lived an average of 12.11 days.

TABLE 7.—*Length of life of adults of the first brood of the European red mite, Yakima, Wash., 1924*

	Male	Female
Number of individuals	14	35
Total—days	117	424
Average length of life—do	8.36	12.11
Maximum length of life—do	15	25
Minimum length of life—do	4	4

LIFE CYCLE OF THE FIRST GENERATION

Tables 8 and 9 give the life cycle of 26 male and 51 female mites, respectively, of the first brood. The average number of days from the hatching of the eggs to the molting of the male deutonymphs was 11.69, while in the case of the females it was 12.88, or a little over a day longer. To this should be added 2.28 days, which is the period before oviposition, as shown in Table 6, making a total of 15.16 days as the complete life cycle from hatching of the winter eggs to the deposition of the earliest first-brood eggs. These tables do not include the incubation period, since these individuals came from winter eggs, and the date of oviposition was not known.

TABLE 8.—*Life cycle of 26 males of the first brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—		Date of nymphal molts		Length of stages in days			
	Hatching	Larval molt	Protonymph	Deutonymph	Larval	Protonymph	Deutonymph	Total
1	Apr. 16	Apr. 22	Apr. 27	Apr. 30	6	5	3	14
2	do	do	do	do	6	5	3	14
3	Apr. 21	Apr. 26	Apr. 28	May 1	5	2	3	10
4	do	do	do	do	5	2	3	10
5	do	do	Apr. 29	May 2	5	3	3	11
6	do	Apr. 27	do	do	6	2	3	11
7	do	do	do	do	6	2	3	11
8	Apr. 22	Apr. 25	Apr. 28	May 4	3	3	6	12
9	do	Apr. 27	Apr. 29	May 3	5	2	4	11
10	do	do	do	do	5	2	4	11
11	do	Apr. 28	May 2	May 6	6	4	4	14
12	do	Apr. 29	May 1	May 5	7	2	4	13
13	Apr. 23	Apr. 28	Apr. 30	May 3	5	2	3	10
14	do	do	do	May 4	5	2	4	11
15	do	do	May 2	May 6	5	4	4	13
16	do	Apr. 29	do	May 8	6	3	6	15
17	Apr. 24	Apr. 28	May 1	May 4	4	3	3	10
18	do	do	do	May 5	4	3	4	11
19	do	Apr. 29	May 2	May 7	5	3	5	13
20	do	do	do	do	5	3	5	13
21	do	do	May 3	May 8	5	4	5	14
22	Apr. 25	Apr. 28	Apr. 30	May 4	3	2	4	9
23	do	do	May 1	May 5	3	3	4	10
24	Apr. 28	May 2	May 6	May 9	4	4	3	11
25	Apr. 29	do	May 4	May 10	3	2	6	11
26	do	do	May 7	do	3	5	3	11
Total					125	77	102	304
Average					4.81	2.96	3.92	11.69
Maximum					7	5	6	15
Minimum					3	2	3	9

TABLE 9.—*Life cycle of 51 females of the first brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—		Date of nymphal molts		Length of stages in days			
	Hatching	Larval molt	Protonymph	Deutonymph	Larval	Protonymph	Deutonymph	Total
1	Apr. 16	Apr. 20	Apr. 26	Apr. 29	4	6	3	13
2	do	Apr. 22	do	do	6	4	3	13
3	do	Apr. 23	Apr. 27	May 1	7	4	4	15
4	do	do	do	do	7	4	4	15
5	do	Apr. 22	Apr. 28	May 2	6	6	4	16
6	Apr. 17	Apr. 23	do	May 1	6	5	3	14
7	Apr. 19	Apr. 24	do	do	5	4	3	12
8	Apr. 20	Apr. 26	Apr. 29	May 2	6	3	3	12
9	Apr. 21	do	do	do	5	3	3	11
10	Apr. 22	do	do	May 4	4	3	5	12
11	do	Apr. 27	do	May 3	5	2	4	11
12	do	do	do	do	5	2	4	11
13	do	do	do	do	5	2	4	11
14	do	do	do	do	5	2	4	11
15	do	do	Apr. 30	do	5	3	3	11
16	do	do	do	May 4	5	3	4	12
17	do	do	do	do	5	3	4	12
18	do	Apr. 28	May 1	May 6	6	3	5	14
19	do	do	do	May 7	6	3	6	15
20	do	do	do	do	6	3	6	15
21	do	Apr. 29	May 2	do	7	3	5	15
22	do	do	do	do	7	3	5	15
23	do	do	do	do	7	3	5	15
24	Apr. 23	Apr. 28	Apr. 30	May 4	5	2	4	11
25	do	do	May 1	May 5	5	3	4	12
26	do	Apr. 29	May 2	May 7	6	3	5	14
27	do	do	do	May 8	6	3	6	15
28	do	do	do	do	6	3	6	15
29	do	do	do	do	6	3	6	15
30	do	Apr. 30	May 4	May 9	7	4	5	16

TABLE 9.—*Life cycle of 51 females of the first brood of the European red mite, Yakima, Wash., 1924*—Continued

No.	Date of—		Date of nymphal molts		Length of stages in days			
	Hatching	Larval molt	Protonymph	Deutonymph	Larval	Protonymph	Deutonymph	Total
31	Apr. 24	Apr. 28	May 1	May 4	4	3	3	10
32	do	Apr. 29	May 2	May 6	5	3	4	12
33	do	do	do	May 7	5	3	5	13
34	do	do	do	do	5	3	5	13
35	do	do	do	do	5	3	5	13
36	do	do	do	do	5	3	5	13
37	do	do	do	May 8	5	3	6	14
38	do	do	May 3	do	5	4	5	14
39	do	Apr. 30	do	do	6	3	5	14
40	Apr. 25	Apr. 29	May 2	May 6	4	3	4	11
41	do	do	do	May 7	4	3	5	12
42	Apr. 26	do	do	do	3	3	5	11
43	do	do	do	do	3	3	5	11
44	do	Apr. 30	May 3	May 8	4	3	5	12
45	do	do	do	May 9	4	3	6	13
46	do	do	do	do	4	3	6	13
47	Apr. 27	May 1	do	May 8	4	2	5	11
48	Apr. 28	May 2	May 7	May 10	4	5	3	12
49	do	do	do	do	4	5	3	12
50	do	do	do	do	4	5	3	12
51	do	do	do	do	4	5	3	12
Total					262	169	226	657
Average					5.14	3.31	4.43	12.88
Maximum					7	6	6	16
Minimum					3	2	3	10

THE SECOND GENERATION

EGGS OF THE SECOND BROOD

TIME OF OVIPOSITION

The time of deposition of the second-brood eggs is shown in Figure 15. The first eggs were deposited May 1, the maximum oviposition occurred May 11, and the last egg was deposited May 31.

LENGTH OF INCUBATION

The incubation period of 961 second-brood eggs averaged 8.29 days, the maximum being 15 and the minimum 6, as is shown in Table 10.

TABLE 10.—*Length of incubation period of 961 eggs of the second brood of the European red mite, Yakima, Wash., 1924*

Length of period	Number of eggs	Length of period	Number of eggs
6 days	12	12 days	14
7 days	253	13 days	3
8 days	383	14 days	1
9 days	167	15 days	1
10 days	75	Average, 8.29 days.	
11 days	52		

TIME OF HATCHING

Figure 15 shows that the second-brood eggs began hatching May 13, that the maximum hatching occurred May 19, and that the last occurred June 6.

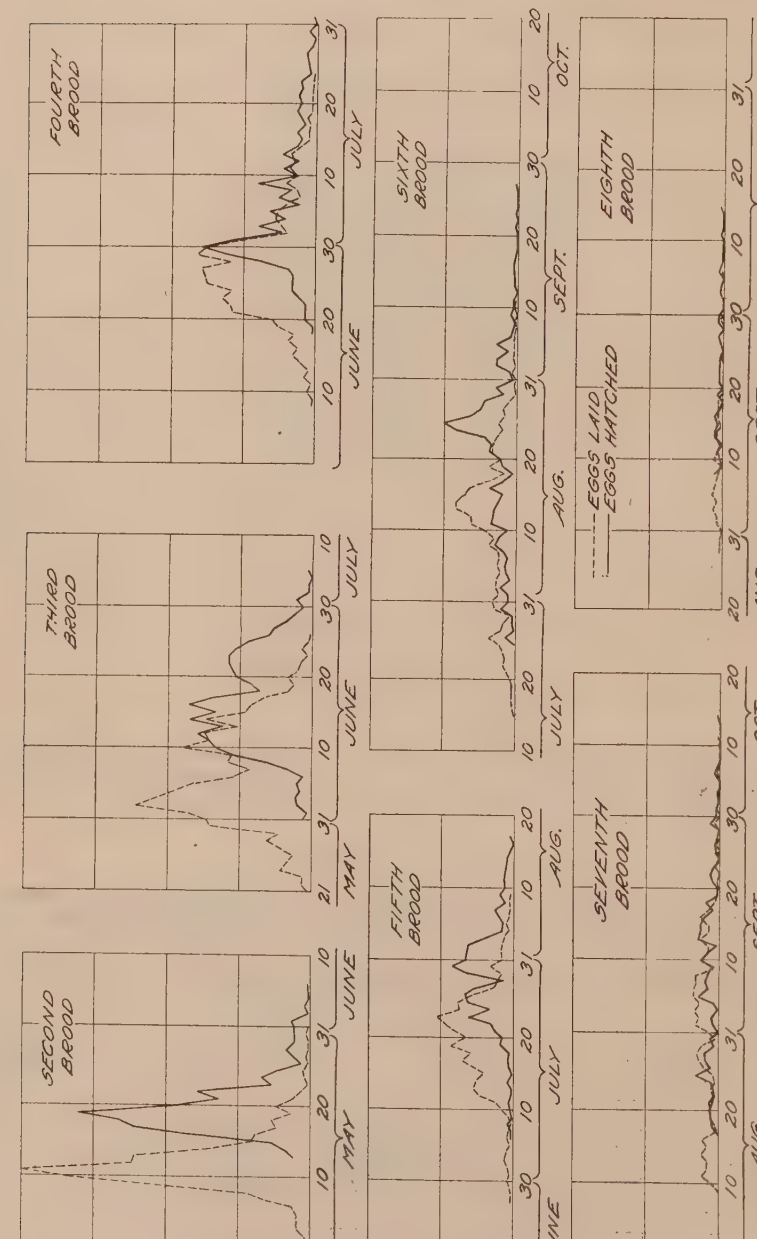


FIGURE 15.—Diagram showing the rate of egg deposition and the rate of hatching of broods of the European red mite during the season of 1924 at Yakima, Wash.

IMMATURE STAGES OF THE SECOND BROOD

LENGTH OF THE LARVAL PERIOD

In the second brood the average larval life was 2.58 days, the maximum 4, and the minimum 2, as shown in Table 11.

TABLE 11.—*Length of larval period of European red mites of the second brood, Yakima, Wash., 1924*

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	49	57	1.16	2	1	66	1.35	3	1	123	2.51	4	2
Female	29	40	1.38	2	1	42	1.45	2	1	82	2.83	4	2
Both sexes	97	120	1.24	2	1	130	1.34	3	1	250	2.58	4	2

LENGTH OF THE NYMPHAL PERIOD

The length of the nymphal period in the second generation is given in Table 12; the average was 4.63 days, the maximum 7, and the minimum 3.

TABLE 12.—*Length of nymphal period of European red mites of the second brood, Yakima, Wash., 1924*

PROTONYMPH

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	45	45	1.00	2	0	51	1.13	2	0	96	2.13	3	1
Female	26	29	1.12	2	1	35	1.35	3	0	64	2.46	4	1
Both sexes	71	74	1.04	2	0	86	1.21	3	0	160	2.25	4	1

DEUTONYMPH

Male	45	45	1.00	2	0	61	1.36	3	1	106	2.36	4	2
Female	26	32	1.23	2	0	31	1.19	2	1	63	2.42	4	2
Both sexes	71	77	1.08	2	0	92	1.30	3	1	169	2.38	4	1

COMBINED TOTAL

Male	45									202	4.49	7	3
Female	26									127	4.88	7	3
Both sexes	71									329	4.63	7	3

ADULTS OF THE SECOND BROOD

OVIPOSITION

The females of the second brood deposited an average of 34.51 eggs, the average interval before oviposition being 1.68 days, the period of oviposition 15.24 days, and the total average period from emergence

to the last oviposition 15.84 days, as Table 13 shows. The total of 91 eggs deposited by one female is rather unusual, though several females deposited over 80 eggs.

TABLE 13.—*Oviposition by females of the second brood of the European red mite, Yakima, Wash., 1924*

Days	Number of days—			Number of eggs deposited by 37 individuals
	Before oviposition (41 individuals)	Of oviposition (37 individuals)	From emergence to last oviposition (37 individuals)	
Total	69	564	586	1,277
Average	1.68	15.24	15.84	34.51
Maximum	4	32	33	91
Minimum	1	5	5	7

LENGTH OF LIFE OF ADULTS

The males of the second brood lived an average of 15.29 days and the females 17, as is indicated in Table 14.

TABLE 14.—*Length of life of adults of the second brood of the European red mite, Yakima, Wash., 1924*

	Male	Female
Number of individuals	31	39
Total ..... days	474	663
Average length of life ..... do	15.29	17
Maximum length of life ..... do	29	34
Minimum length of life ..... do	6	4

LIFE CYCLE OF THE SECOND GENERATION

The complete life cycle of 47 males and 26 females of the second brood is given in Tables 15 and 16. The average life cycle was 15.54 days for the males and 16.08 days for the females, to which must be added 1.68 days, the period before oviposition, making a total of 17.76 days for the complete life cycle of the second generation.

TABLE 15.—*Life cycle of 47 males of the second brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	May 1	May 13	May 15	May 16	May 18	12	2	1	2	17
2	May 2	do	do	do	do	11	2	1	2	16
3	May 3	do	do	May 17	May 19	10	2	2	2	16
4	May 7	May 15	May 17	May 19	May 21	8	2	2	2	14
5	May 9	May 17	May 19	May 21	May 23	8	2	2	2	14
6	do	do	May 20	do	do	8	3	1	2	14
7	do	do	do	May 22	May 24	8	3	2	2	15
8	do	do	do	do	do	8	3	2	2	15
9	May 10	May 16	May 18	May 20	May 22	6	2	2	2	12
10	do	May 17	May 19	May 21	May 23	7	2	2	2	13
11	do	May 18	May 20	May 22	do	8	2	2	1	13
12	do	do	do	do	May 24	8	2	2	2	14
13	do	do	do	do	do	8	2	2	2	14
14	do	do	do	do	do	8	2	2	2	14
15	do	do	do	do	do	8	2	2	2	14
16	do	May 20	May 24	May 27	May 31	10	4	3	4	21
17	May 11	May 19	May 21	May 22	May 24	8	2	1	2	13
18	do	do	do	May 23	May 25	8	2	2	2	14
19	do	do	do	do	do	8	2	2	2	14
20	do	do	do	do	do	8	2	2	2	14
21	do	do	do	do	May 26	8	2	2	3	15
22	do	do	do	do	do	8	2	2	3	15
23	do	do	May 22	do	May 25	8	3	1	2	14
24	do	do	do	May 24	May 27	8	3	2	3	16
25	do	May 20	do	do	do	9	2	2	3	16
26	do	do	do	do	May 28	9	2	2	4	17
27	do	do	do	do	do	9	2	2	4	17
28	May 13	do	do	do	May 27	7	2	2	3	14
29	do	May 21	May 23	May 25	do	8	2	2	2	14
30	do	do	do	do	May 28	8	2	2	3	15
31	do	do	do	do	May 29	8	2	2	4	16
32	do	do	May 24	May 27	May 30	8	3	3	3	17
33	do	May 22	May 25	May 28	May 31	9	3	3	3	18
34	do	May 23	May 24	May 26	May 29	10	1	2	3	16
35	May 14	May 22	do	May 27	May 30	8	2	3	3	16
36	do	do	do	do	do	8	2	3	3	16
37	do	May 23	May 26	May 30	June 1	9	3	4	2	18
38	May 15	May 24	do	May 29	May 31	9	2	3	2	16
39	do	do	May 27	May 30	June 1	9	3	3	2	17
40	do	do	May 28	May 31	June 2	9	4	3	2	18
41	May 16	May 25	do	May 30	June 1	9	3	2	2	16
42	do	do	do	May 31	June 2	9	3	3	2	17
43	do	do	May 29	do	do	9	4	2	2	17
44	do	May 27	May 30	June 1	do	11	3	2	1	17
45		do	do	do	June 3		3	2	2	
46	May 20	May 31	June 2	June 4	June 6	11	2	2	2	17
47	May 22	June 2	June 4	June 7	June 10	11	2	3	3	19
Total						[1] 397	112	101	112	[1] 715
Average						8.63	2.38	2.15	2.38	15.54
Maximum						12	4	4	4	21
Minimum						6	1	1	1	12

[1] 46 individuals.

TABLE 16.—*Life cycle of 26 females of the second brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	May 3	May 13	May 15	May 17	May 19	10	2	2	2	16
2	May 6	May 16	May 18	May 20	May 22	10	2	2	2	16
3	May 8	do	do	do	do	8	2	2	2	14
4	do	do	May 19	May 21	May 23	8	3	2	2	15
5	May 9	do	May 18	May 20	May 22	7	2	2	2	13
6	do	May 17	May 19	May 21	May 23	8	2	2	2	14
7	do	do	May 20	do	do	8	3	1	2	14
8	May 10	do	May 19	do	do	7	2	2	2	13
9	do	do	do	do	do	7	2	2	2	13
10	May 11	May 19	May 21	May 23	May 25	8	2	2	2	14
11	do	do	do	do	May 26	8	2	2	3	15
12	do	May 20	May 22	May 24	May 28	9	2	2	4	17
13	May 12	do	May 23	May 25	do	8	3	2	3	16
14	May 13	May 21	May 24	May 27	May 30	8	3	3	3	17
15	May 14	May 22	do	do	May 31	8	2	3	4	17
16	do	May 23	May 26	May 30	June 1	9	3	4	2	18
17	do	May 24	May 27	do	June 2	10	3	3	3	19
18	May 15	May 23	do	May 29	June 1	8	4	2	3	17
19	do	do	do	May 30	do	8	4	3	2	17
20	do	do	do	do	June 2	8	4	3	3	18
21	do	do	do	May 31	do	8	4	4	2	18
22	do	May 24	do	do	do	9	3	4	2	18
23	May 16	do	May 28	do	do	8	4	3	2	17
24	do	May 26	May 30	June 1	June 3	10	4	2	2	18
25	May 18	May 25	May 29	May 31	June 2	7	4	2	2	15
26	May 22	June 2	June 4	June 7	June 10	11	2	3	3	19
Total						218	73	64	63	418
Average						8.38	2.81	2.46	2.42	16.08
Maximum						11	4	4	4	19
Minimum						7	2	1	2	13

THE THIRD GENERATION

EGGS OF THE THIRD BROOD

TIME OF OVIPOSITION

Third-brood eggs were deposited from May 21 to June 26, the maximum deposition occurring on June 2, as is shown in Figure 15.

LENGTH OF INCUBATION

Incubation records of 1,244 third-brood eggs are given in Table 17. The average incubation period was 10.04 days, the maximum 15, and the minimum 6.

TABLE 17.—*Length of incubation period of 1,244 eggs of the third brood of the European red mite, Yakima, Wash., 1924*

Length of period	Number of eggs	Length of period	Number of eggs
6 days	5	12 days	70
7 days	14	13 days	17
8 days	57	14 days	2
9 days	282	15 days	1
10 days	498	Average, 10.04 days.	
11 days	298		

TIME OF HATCHING

These eggs hatched from May 31 to July 5, as is shown in Figure 15, the period of maximum hatching being from June 12 to 16.

IMMATURE STAGES OF THE THIRD BROOD

LENGTH OF THE LARVAL PERIOD

Table 18 gives the average length of the larval period of 110 individuals of the third brood as 2.65 days, the maximum 4, and the minimum 1.

TABLE 18.—*Length of larval period of European red mites of the third brood, Yakima, Wash., 1924*

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	33	38	1.15	2	1	41	1.24	2	0	79	2.39	3	1
Female	56	82	1.46	2	1	72	1.29	3	1	154	2.75	4	2
Both sexes	110	146	1.33	2	1	145	1.32	3	0	291	2.65	4	1

LENGTH OF THE NYMPHAL PERIOD

The length of nymphal period of the third brood, which is given in Table 19, averaged 4.9 days, the maximum being 7 and the minimum 3.

TABLE 19.—*Length of nymphal period of European red mites of the third brood, Yakima, Wash., 1924*

PROTONYMPH

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	31	38	1.23	2	1	37	1.19	2	0	73	2.35	3	1
Female	56	64	1.14	2	1	64	1.14	2	0	130	2.32	4	1
Both sexes	87	102	1.17	2	1	101	1.16	2	0	203	2.33	4	1

DEUTONYMPH

Male	31	36	1.16	2	1	40	1.29	2	1	76	2.45	4	2
Female	56	69	1.23	2	1	78	1.39	3	1	147	2.63	4	2
Both sexes	87	105	1.21	2	1	118	1.36	3	1	223	2.56	4	2

COMBINED TOTAL

Male	31									149	4.81	6	3
Female	56									277	4.95	7	4
Both sexes	87									426	4.90	7	3

ADULTS OF THE THIRD BROOD

OVIPOSITION

Table 20 gives oviposition records of third-brood females. There was an average preoviposition period of 1.74 days, an average oviposition period of 10.71 days, and an average total period from emergence to last oviposition of 11.45 days. The females deposited an average of 25.52 eggs.

TABLE 20.—*Oviposition by 31 females of the third brood of the European red mite, Yakima, Wash., 1924*

Days	Number of days—			Number of eggs deposited
	Before oviposition	Of oviposition	From emergence to last oviposition	
Total	54	332	355	791
Average	1.74	10.71	11.45	25.52
Maximum	3	20	21	59
Minimum	1	3	4	9

LENGTH OF LIFE OF ADULTS

Males of the third brood lived an average of 10.65 days, and females lived 12.69 days, as shown in Table 21.

TABLE 21.—*Length of life of adults of the third brood of the European red mite, Yakima, Wash., 1924*

	Male	Female
Number of individuals	20	35
Total days	213	444
Average length of life do	10.65	12.69
Maximum length of life do	17	22
Minimum length of life do	6	6

LIFE CYCLE OF THE THIRD GENERATION

The complete life cycle of 31 males and 54 females of the third generation is shown in Tables 22 and 23. The average was 17.03 days for the males and 17.70 days for the females, to which should be added 1.74 days, the preoviposition period, making a complete life cycle of 19.44 days.

TABLE 22.—*Life cycle of 31 males of the third brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	May 23	June 2	June 5	June 8	June 11	10	3	3	3	19
2	May 24	do	June 4	June 6	June 10	9	2	2	4	17
3	do	do	do	June 7	do	9	2	3	3	17
4	do	June 3	June 5	June 8	June 11	10	2	3	3	18
5	do	do	do	do	do	10	2	3	3	18
6	May 27	June 5	June 8	June 11	June 13	9	3	3	2	17
7	May 28	June 6	June 9	June 12	June 14	9	3	3	2	17
8	May 30	June 9	June 11	June 14	June 16	10	2	3	2	17
9	May 31	do	June 12	do	June 17	9	3	2	3	17
10	do	June 10	do	June 15	June 18	10	2	3	3	18
11	do	do	June 13	do	do	10	3	2	3	18
12	June 1	June 12	June 14	June 16	June 19	11	2	2	3	18
13	June 2	June 11	do	do	do	9	3	2	3	17
14	June 3	June 14	June 16	June 19	June 21	11	2	3	2	18
15	June 4	do	do	do	June 22	10	2	3	3	18
16	June 5	June 16	June 19	June 21	June 23	11	3	2	2	18
17	do	June 17	June 20	June 22	June 24	12	3	2	2	19
18	June 6	June 16	June 19	June 21	June 23	10	3	2	2	17
19	June 7	June 17	June 20	June 22	June 24	10	3	2	2	17
20	June 9	June 18	do	June 23	June 25	9	2	3	2	16
21	June 10	June 19	June 21	do	June 26	9	2	2	3	16
22	do	June 23	June 25	June 27	June 29	13	2	2	2	19
23	June 11	June 22	June 24	June 25	June 28	11	2	1	3	17
24	June 13	June 23	June 25	June 27	June 29	10	2	2	2	16
25	do	do	do	do	do	10	2	2	2	16
26	do	do	do	June 28	June 30	10	2	3	2	17
27	June 14	June 25	June 28	June 29	July 1	11	3	1	2	17
28	June 16	do	June 27	do	do	9	2	2	2	15
29	June 21	June 30	July 2	July 4	July 6	9	2	2	2	15
30	June 22	do	July 1	July 3	July 5	8	1	2	2	13
31	June 25	July 3	July 6	July 9	July 11	8	3	3	2	16
Total						306	73	73	76	528
Average						9.87	2.35	2.35	2.45	17.03
Maximum						13	3	3	4	19
Minimum						8	1	1	2	13

TABLE 23.—*Life cycle of 54 females of the third brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	May 21	May 31	June 2	June 4	June 8	10	2	2	4	18
2	do	do	do	do	June 6	10	2	2	2	16
3	May 24	June 3	June 7	June 10	June 13	10	4	3	3	20
4	May 25	June 4	June 8	do	do	10	4	2	3	19
5	May 27	June 7	June 10	June 12	June 16	11	3	2	4	20
6	May 28	June 6	do	do	June 15	9	4	2	3	18
7	do	June 7	do	do	do	10	3	2	3	18
8	do	June 8	June 11	June 14	June 16	11	3	3	2	19
9	May 29	June 7	June 10	June 13	June 15	9	3	3	2	17
10	do	June 8	June 12	June 14	June 16	10	4	2	2	18
11	May 30	do	June 11	June 13	do	9	3	2	3	17
12	do	June 10	June 13	June 16	June 20	11	3	3	4	21
13	May 31	June 9	June 12	June 14	June 16	9	3	2	2	16
14	do	do	June 13	June 15	June 17	9	4	2	2	17
15	do	June 10	June 12	do	do	10	2	3	2	17
16	do	do	June 13	do	June 18	10	3	2	3	18
17	June 1	June 11	do	June 16	June 19	10	2	3	3	18
18	June 2	June 9	June 12	June 15	June 17	7	3	3	2	15
19	do	June 11	June 14	June 16	June 19	9	3	2	3	17
20	do	do	do	do	do	9	3	2	3	17
21	do	do	do	June 17	June 20	9	3	3	3	18
22	do	June 14	June 17	June 19	June 22	12	3	2	3	20
23	June 3	June 13	June 16	do	do	10	3	3	3	19
24	do	June 14	do	do	do	11	2	3	3	19
25	June 4	do	do	June 18	do	10	2	2	4	18
26	do	June 15	June 18	June 21	June 23	11	3	3	2	19
27	do	June 16	June 19	do	June 24	12	3	2	3	20
28	June 5	do	June 18	June 22	June 25	11	2	4	3	20
29	do	do	June 19	do	June 24	11	3	3	2	19
30	do	June 17	June 20	do	June 25	12	3	2	3	20
31	June 6	June 16	June 19	do	June 24	10	3	3	2	18
32	do	do	June 20	do	do	10	4	2	2	18
33	June 7	June 19	June 22	June 24	June 26	12	3	2	2	19
34	June 8	June 17	June 20	June 22	June 25	9	3	2	3	17
35	June 9	June 18	June 21	June 23	do	9	3	2	2	16
36	do	do	do	do	do	9	3	2	2	16
37	do	do	do	do	do	9	3	2	2	16
38	do	do	do	do	June 26	9	3	2	3	17
39	do	June 19	do	June 24	June 27	10	2	3	3	18
40	do	June 20	June 22	do	do	11	2	2	3	18
41	do	do	do	June 25	do	11	2	3	2	18
42	June 10	June 21	June 23	do	June 28	11	2	2	3	18
43	do	June 23	June 25	June 28	June 30	13	2	3	2	20
44	June 11	June 21	June 24	June 26	June 28	10	3	2	2	17
45	June 12	June 23	June 26	June 28	June 30	11	3	2	2	18
46	June 13	June 24	do	do	July 1	11	2	2	3	18
47	June 14	June 23	June 25	June 27	June 29	9	2	2	2	15
48	do	do	do	do	do	9	2	2	2	15
49	June 15	June 25	June 27	June 29	July 1	10	2	2	2	16
50	June 16	do	do	do	do	9	2	2	2	15
51	do	June 26	June 28	June 30	July 3	10	2	2	3	17
52	June 17	June 27	June 29	July 1	do	10	2	2	2	16
53	do	do	June 30	do	July 4	10	3	1	3	17
54	June 18	do	June 29	do	July 3	9	2	2	2	15
Total						543	148	125	140	956
Average						10.06	2.74	2.31	2.59	17.7
Maximum						13	4	4	4	21
Minimum						7	2	1	2	15

THE FOURTH GENERATION

EGGS OF THE FOURTH BROOD

TIME OF OVIPOSITION

Fourth-brood eggs were deposited from June 8 to July 24, the maximum deposition occurring on June 29, as is shown in Figure 15. This is a longer oviposition period than the earlier broods had.

LENGTH OF INCUBATION

The average incubation period of 738 fourth-brood eggs was 8.33 days, the maximum being 14 and the minimum 5. The detailed records are given in Table 24.

TABLE 24.—*Length of incubation period of 738 eggs of the fourth brood of the European red mite, Yakima, Wash., 1924*

Length of period	Number of eggs	Length of period	Number of eggs
5 days	7	11 days	13
6 days	18	12 days	3
7 days	140	13 days	0
8 days	254	14 days	1
9 days	218	Average, 8.33 days.	
10 days	84		

TIME OF HATCHING

In Figure 15 are given the dates of hatching. This period extended from June 18 to August 1; the maximum number hatched on June 30.

IMMATURE STAGES OF THE FOURTH BROOD

LENGTH OF THE LARVAL PERIOD

The larval period of the fourth brood averaged 2.65 days, as Table 25 shows; the maximum was 4 and the minimum 2.

TABLE 25.—*Length of larval period of European red mites of the fourth brood, Yakima, Wash., 1924*

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	27	38	1.41	2	1	33	1.22	2	1	71	2.63	4	2
Female	35	52	1.49	2	1	44	1.26	2	1	96	2.74	4	2
Both sexes	77	111	1.44	3	1	93	1.21	2	1	204	2.65	4	2

LENGTH OF THE NYMPHAL PERIOD

The nymphal period of the fourth brood extended over an average of 4.81 days, the maximum being 9 and the minimum 3, as is indicated in Table 26.

TABLE 26.—*Length of nymphal period of European red mites of the fourth brood. Yakima, Wash., 1924*

PROTONYMPH

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	24	29	1.21	2	1	26	1.08	2	1	55	2.29	4	2
Female	35	40	1.14	2	1	41	1.17	2	1	81	2.31	3	2
Both sexes	59	69	1.17	2	1	67	1.14	2	1	136	2.31	4	2

DEUTONYMPH

Male	24	27	1.13	3	1	28	1.17	2	0	55	2.29	5	1
Female	35	48	1.37	2	1	45	1.29	3	0	93	2.66	4	1
Both sexes	59	75	1.27	3	1	73	1.24	3	0	148	2.51	5	1

COMBINED TOTAL

Male	24									110	4.58	9	3
Female	35									174	4.97	7	3
Both sexes	59									284	4.81	9	3

ADULTS OF THE FOURTH BROOD

OVIPOSITION

Female mites of the fourth brood deposited an average of 15.68 eggs, the preoviposition period averaging 2.12 days, the oviposition period 8.76 days, and the total period from emergence to last oviposition 9.88 days. These figures are given in Table 27.

TABLE 27.—*Oviposition by 25 females of the fourth brood of the European red mite. Yakima, Wash., 1924*

Days	Number of days—			Number of eggs deposited
	Before oviposition	Of oviposition	From emergence to last oviposition	
Total	53	219	247	392
Average	2.12	8.76	9.88	15.68
Maximum	4	17	18	43
Minimum	1	2	3	3

LENGTH OF LIFE OF ADULTS

Table 28 shows that fourth-brood males lived an average of 11.18 days and females an average of 11.91 days.

TABLE 28.—*Length of life of adults of the fourth brood of the European red mite, Yakima, Wash., 1924*

		Male	Female
Number of individuals		22	24
Total	days	190	274
Average length of life	do	11.82	11.91
Maximum length of life	do	22	20
Minimum length of life	do	5	4

LIFE CYCLE OF THE FOURTH GENERATION

Records of the life cycle of fourth-brood males and females are given in Tables 29 and 30, respectively. The development of 22 males occupied an average of 15.55 days, and that of 34 females 15.82 days, or, adding 2.12 days for the preoviposition period, a total of 17.94 days for the females.

TABLE 29.—*Life cycle of 22 males of the fourth brood of the European red mite, Yakima, Wash., 1924*

No.	Date of			Date of nymphal molts		Length of stage in days				
	Egg deposited	Hatching	Larval molt	Proto-nymph	Deuto-nymph	Egg	Larval	Proto-nymph	Deuto-nymph	Total
1	June 10	June 20	June 22	June 24	June 26	10	2	2	2	16
2	June 17	June 26	June 28	June 30	July 1	9	2	2	1	14
3	do	do	June 29	July 1	July 3	9	3	2	2	16
4	June 20	June 29	July 1	July 4	July 6	9	2	3	2	16
5	June 22	June 30	July 3	July 5	July 7	8	3	2	2	15
6	June 23	July 1	July 4	July 6	July 9	8	3	2	3	16
7	June 25	July 4	July 7	July 9	July 11	9	3	2	2	16
8	June 27	July 5	July 8	July 10	July 12	8	3	2	2	15
9	do	do	July 9	July 11	July 13	8	4	2	2	16
10	June 29	do	July 3	July 19	July 12	6	3	2	2	13
11	do	July 7	July 10	July 14	July 19	8	3	4	5	20
12	do	July 9	July 11	July 13	July 15	10	2	2	2	16
13	June 30	July 8	do	do	do	8	3	2	2	15
14	do	July 9	July 12	July 14	July 17	9	3	2	3	17
15	July 2	do	July 11	July 13	July 15	7	2	2	2	13
16	do	do	July 12	July 15	July 18	7	3	3	3	16
17	do	July 10	do	do	do	8	2	3	3	16
18	July 4	July 12	July 14	July 17	July 19	8	2	3	2	15
19	July 5	July 13	July 15	July 18	July 20	8	2	3	2	15
20	July 6	July 15	July 17	July 19	July 22	9	2	2	3	16
21	July 10	July 19	July 21	July 23	July 25	9	2	2	2	15
22	July 11	do	July 22	July 24	July 26	8	3	2	2	15
Total						183	57	51	51	342
Average						8.32	2.59	2.32	2.32	15.55
Maximum						10	4	4	5	20
Minimum						6	2	2	1	13

TABLE 30.—*Life cycle of 34 females of the fourth brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	June 10	June 20	June 22	June 24	June 25	10	2	2	1	15
2	June 16	June 25	June 27	June 30	July 1	9	2	3	1	15
3	June 17	June 26	June 29	July 1	July 5	9	3	2	4	18
4	June 23	July 1	July 3	July 5	July 8	8	2	2	3	15
5	do	do	July 4	July 6	July 9	8	3	2	3	16
6	do	do	July 5	July 8	July 10	8	4	3	2	17
7	June 24	do	July 3	July 5	July 8	7	2	2	3	14
8	do	July 2	July 5	July 7	July 11	8	3	2	4	17
9	do	do	do	July 8	July 10	8	3	3	2	16
10	June 25	July 3	July 6	do	July 11	8	3	2	3	16
11	do	do	July 8	July 10	July 13	8	5	2	3	18
12	June 26	do	July 5	July 7	July 10	7	2	2	3	14
13	do	do	July 6	July 8	July 11	7	3	2	3	15
14	June 27	July 5	July 7	July 10	July 13	8	2	3	3	16
15	do	July 6	July 9	July 11	do	9	3	2	2	16
16	June 29	do	do	do	do	7	3	2	2	14
17	do	do	do	do	do	7	3	2	2	14
18	do	July 7	do	July 12	July 14	8	2	3	2	15
19	June 30	July 8	July 10	do	do	8	2	2	2	14
20	do	do	do	July 13	July 15	8	2	3	2	15
21	do	do	July 12	July 15	July 18	8	4	3	3	18
22	do	July 9	July 11	July 13	July 15	9	2	2	2	15
23	do	do	July 12	July 14	July 17	9	3	2	3	17
24	do	July 10	do	do	do	10	2	2	3	17
25	do	do	July 13	July 16	July 19	10	3	3	3	19
26	July 1	July 8	July 10	July 12	July 14	7	2	2	2	13
27	July 2	July 10	July 12	July 14	July 16	8	2	2	2	14
28	July 3	July 11	July 13	July 15	July 19	8	2	2	4	16
29	do	do	July 14	July 16	do	8	3	2	3	16
30	July 4	July 12	July 15	July 17	July 20	8	3	2	3	16
31	do	do	do	do	July 21	8	3	2	4	17
32	do	July 13	do	July 18	do	9	2	3	3	17
33	July 9	July 17	July 19	July 22	July 26	8	2	3	4	17
34	July 13	July 23	July 25	July 27	July 29	10	2	2	2	16
Total						280	89	78	91	538
Average						8.24	2.62	2.29	2.68	15.82
Maximum						10	5	3	4	19
Minimum						7	2	2	1	13

THE FIFTH GENERATION

EGGS OF THE FIFTH BROOD

TIME OF OVIPOSITION

Figure 15 shows that fifth-brood eggs were laid from June 27 to August 9, with a maximum on July 23.

LENGTH OF INCUBATION

The length of incubation of the fifth-brood eggs averaged 8.56 days, an indicated in Table 31, the maximum being 12 and the minimum 5.

TABLE 31.—*Length of incubation period of 485 eggs of the fifth brood of the European red mite, Yakima, Wash., 1924*

Length of period	Number of eggs	Length of period	Number of eggs
5 days	2	10 days	57
6 days	5	11 days	7
7 days	40	12 days	1
8 days	182	Average, 8.56 days.	
9 days	191		

TIME OF HATCHING

In Figure 15 it is seen that the fifth-brood eggs hatched from July 6 to August 17, with a maximum number on July 30.

IMMATURE STAGES OF THE FIFTH BROOD

LENGTH OF THE LARVAL PERIOD

The length of the larval period of 76 individuals of the fifth brood is shown in Table 32. It averaged 2.82 days, the maximum being 5 and the minimum 2.

TABLE 32.—*Length of larval period of European red mites of the fifth brood, Yakima, Wash., 1924*

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	18	27	1.50	3	1	21	1.17	2	1	48	2.67	4	2
Female	44	75	1.70	3	1	52	1.18	2	1	127	2.89	5	2
Both sexes	76	126	1.66	3	1	88	1.16	2	1	214	2.82	5	2

LENGTH OF THE NYMPHAL PERIOD

The nymphal period of the fifth brood was 5.15 days on the average, as is shown in Table 33, the maximum being 8 and the minimum 3.

TABLE 33.—*Length of nymphal period of European red mites of the fifth brood, Yakima, Wash., 1924*

PROTONYMPH

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	17	22	1.29	2	1	16	0.94	1	0	38	2.24	3	1
Female	43	64	1.49	4	1	48	1.12	2	1	112	2.60	5	2
Both sexes	60	86	1.43	4	1	64	1.07	2	0	150	2.50	5	1

DEUTONYMPH

Male	17	20	1.18	3	1	21	1.24	2	2	41	2.41	4	2
Female	43	65	1.51	3	1	53	1.23	2	1	118	2.74	4	2
Both sexes	60	85	1.42	3	1	74	1.23	2	1	159	2.65	4	2

COMBINED TOTAL

Male	17									79	4.65	7	3
Female	43									230	5.35	8	4
Both sexes	60									309	5.15	8	3

ADULTS OF THE FIFTH BROOD

OVIPOSITION

Female mites of the fifth brood had an average preoviposition period of 2.12 days, an average oviposition period of 11.88 days, and an average period from emergence to last oviposition of 13 days, as is shown in Table 34. The average number of eggs deposited was 15.52.

TABLE 34.—*Oviposition by 25 females of the fifth brood of the European red mite, Yakima, Wash., 1924*

Days	Number of days—			Number of eggs deposited
	Before oviposition	Of oviposition	From emergence to last oviposition	
Total	53	297	325	388
Average	2.12	11.88	13	15.52
Maximum	6	25	26	49
Minimum	1	3	3	2

LENGTH OF LIFE OF ADULTS

Table 35 shows that males of the fifth brood lived an average of 8.85 days and females an average of 14.33 days.

TABLE 35.—*Length of life of adults of the fifth brood of the European red mite, Yakima, Wash., 1924*

	Male	Female
Number of individuals	13	27
Total—days	115	387
Average length of life—do	8.85	14.33
Maximum length of life—do	19	29
Minimum length of life—do	4	3

LIFE CYCLE OF THE FIFTH GENERATION

Tables 36 and 37 give the life cycles of 17 males and 43 females of the fifth brood. The life cycles of the males occupied an average of 16 days from egg deposition to maturity, while the same period for the females averaged 16.73 days. Adding the preoviposition period of 2.12 days to this gives a total of 18.85 days as the average complete life cycle of females of the fifth brood.

TABLE 36.—*Life cycle of 17 males of the fifth brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	July 2	July 8	July 10	July 12	July 14	6	2	2	2	12
2	July 15	July 25	July 29	Aug. 1	Aug. 5	10	4	3	4	21
3	July 18	do	July 28	July 30	Aug. 1	7	3	2	2	14
4	do	July 27	July 30	Aug. 2	Aug. 4	9	3	3	2	17
5	do	July 29	July 31	do	Aug. 5	11	2	2	3	18
6	July 19	July 27	do	Aug. 1	Aug. 6	8	4	1	5	18
7	do	July 29	do	Aug. 3	do	10	2	3	3	18
8	July 20	do	do	Aug. 2	Aug. 5	9	2	2	3	16
9	July 21	July 30	Aug. 2	Aug. 5	Aug. 7	9	3	3	2	17
10	July 24	Aug. 1	Aug. 3	do	do	8	2	2	2	14
11	do	Aug. 2	Aug. 4	Aug. 6	Aug. 8	9	2	2	2	15
12	do	do	do	Aug. 7	Aug. 9	9	2	3	2	16
13	do	do	Aug. 6	Aug. 8	Aug. 10	9	4	2	2	17
14	July 25	Aug. 3	do	Aug. 7	Aug. 9	9	3	1	2	15
15	July 26	do	Aug. 5	do	do	8	2	2	2	14
16	July 27	Aug. 5	Aug. 7	Aug. 9	Aug. 11	9	2	2	2	15
17	July 30	Aug. 8	Aug. 10	Aug. 12	Aug. 14	9	2	2	2	15
Total						149	44	37	42	272
Average						8.77	2.59	2.18	2.47	16
Maximum						11	4	3	5	21
Minimum						6	2	1	2	12

TABLE 37.—*Life cycle of 43 females of the fifth brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	June 29	July 6	July 9	July 11	July 14	7	3	2	3	15
2	June 30	July 9	July 11	July 13	July 17	9	2	2	4	17
3	July 4	July 11	July 13	July 15	do	7	2	2	2	13
4	July 5	July 12	July 14	July 16	July 19	7	2	2	3	14
5	July 6	July 14	July 17	July 20	July 22	8	3	3	2	16
6	July 9	July 17	July 20	July 23	July 25	8	3	3	2	16
7	do	July 18	July 21	do	July 26	9	3	2	3	17
8	July 11	July 21	July 24	July 26	July 28	10	3	2	2	17
9	July 12	do	July 23	do	do	9	2	3	2	16
10	do	do	July 24	do	July 30	9	3	2	4	18
11	July 14	July 23	July 26	July 30	Aug. 3	9	3	4	4	20
12	July 17	July 26	July 31	Aug. 2	Aug. 6	9	5	2	4	20
13	July 18	do	July 29	Aug. 1	Aug. 3	8	3	3	2	16
14	July 19	July 28	July 31	Aug. 4	Aug. 8	9	3	4	4	20
15	do	July 29	Aug. 1	Aug. 3	Aug. 6	10	3	2	3	18
16	July 20	do	July 31	Aug. 2	do	9	2	2	4	17
17	do	do	do	Aug. 3	do	9	2	3	3	17
18	do	do	Aug. 1	do	Aug. 7	9	3	2	4	18
19	do	do	Aug. 2	Aug. 5	do	9	4	3	2	18
20	do	July 30	Aug. 3	Aug. 6	Aug. 9	10	4	3	3	20
21	July 21	July 28	July 31	Aug. 2	Aug. 4	7	3	2	2	14
22	do	July 30	Aug. 2	Aug. 5	Aug. 9	9	3	3	4	19
23	do	do	do	Aug. 7	Aug. 10	9	3	5	3	20
24	do	do	Aug. 3	do	do	9	4	4	3	20
25	July 22	do	Aug. 2	Aug. 6	Aug. 9	8	3	4	3	18
26	July 23	Aug. 1	Aug. 4	Aug. 7	do	9	3	3	2	17
27	July 25	do	Aug. 3	Aug. 6	do	7	2	3	3	15
28	do	do	Aug. 4	Aug. 7	Aug. 10	7	3	3	3	16
29	do	Aug. 2	do	Aug. 6	Aug. 9	8	2	2	3	15
30	do	do	Aug. 5	Aug. 7	do	8	3	2	2	15
31	do	do	do	do	Aug. 10	8	3	2	3	16
32	do	Aug. 3	Aug. 6	Aug. 8	do	9	3	2	2	16
33		Aug. 2	Aug. 5	do	Aug. 11	--------	3	3	3	--------
34		Aug. 5	Aug. 8	Aug. 10	Aug. 12	--------	3	2	2	--------
35	July 26	do	do	do	do	10	3	2	2	17
36	do	do	do	do	Aug. 13	10	3	2	3	18
37	July 27	do	do	do	Aug. 12	9	3	2	2	16
38	July 29	Aug. 6	do	do	do	8	2	2	2	14
39	do	do	Aug. 9	Aug. 11	Aug. 13	8	3	2	2	15
40	July 30	Aug. 8	Aug. 11	Aug. 13	Aug. 15	9	3	2	2	16
41	July 31	do	Aug. 10	Aug. 12	Aug. 14	8	2	2	2	14
42	Aug. 1	Aug. 9	Aug. 12	Aug. 14	Aug. 16	8	3	2	2	15
43	Aug. 7	Aug. 14	Aug. 16	Aug. 21	Aug. 24	7	2	5	3	17
Total						[1] 349	123	112	118	[1] 686
Average						8.51	2.86	2.60	2.74	16.73
Maximum						10	5	5	4	20
Minimum						7	2	2	2	13

[1] 41 individuals.

THE SIXTH GENERATION

EGGS OF THE SIXTH BROOD

TIME OF OVIPOSITION

As is shown in Figure 15, sixth-brood eggs were deposited from July 15 to September 11, with a maximum oviposition period from August 11 to 16.

LENGTH OF INCUBATION

The incubation period of 587 sixth-brood eggs averaged 9.23 days, the maximum 17 and the minimum 6, as Table 38 shows.

TABLE 38.—*Length of incubation period of 587 eggs of the sixth brood of the European red mite, Yakima, Wash., 1924*

Length of period	Number of eggs	Length of period	Number of eggs
6 days	11	12 days	12
7 days	58	13 days	5
8 days	128	14 days	2
9 days	118	17 days	1
10 days	165	Average, 9.23 days.	
11 days	87		

TIME OF HATCHING

Figure 15 gives the time of hatching. This extended from July 25 to September 27; the maximum number of eggs hatched on August 25.

IMMATURE STAGES OF THE SIXTH BROOD

LENGTH OF THE LARVAL PERIOD

The larval period of the sixth brood averaged 3.11 days, the maximum being 7 and the minimum 2, as shown in Table 39.

TABLE 39.—*Length of larval period of European red mites of the sixth brood, Yakima, Wash., 1924*

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	29	49	1.69	3	1	31	1.07	2	1	80	2.76	4	2
Female	39	82	2.10	6	1	48	1.23	3	1	130	3.33	7	2
Both sexes	92	176	1.91	6	1	110	1.20	3	1	286	3.11	7	2

LENGTH OF THE NYMPHAL PERIOD

Table 40 shows that the nymphal period of the sixth brood averaged 6.76 days, the maximum being 23 and the minimum 4. The nymph requiring 23 days to develop emerged late in the year when the weather was cool.

TABLE 40.—*Length of nymphal period of European red mites of the sixth brood, Yakima, Wash., 1924*

PROTONYMPH

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	26	36	1.38	3	1	34	1.31	5	1	70	2.69	6	2
Female	36	74	2.06	6	1	50	1.39	5	1	124	3.44	8	2
Both sexes	62	110	1.77	6	1	84	1.35	5	1	194	3.13	8	2

DEUTONYMPH

Male	26	41	1.58	4	1	38	1.46	4	1	79	3.04	6	2
Female	36	84	2.33	11	1	62	1.72	6	1	146	4.06	16	2
Both sexes	62	125	2.02	11	1	100	1.61	6	1	225	3.63	16	2

COMBINED TOTAL

Male	26									149	5.73	10	4
Female	36									270	7.50	23	4
Both sexes	62									419	6.76	23	4

ADULTS OF THE SIXTH BROOD

OVIPOSITION

Oviposition records for adults of the sixth brood are given in Table 41. The preoviposition period averaged 2.9 days, the oviposition period 14.5 days, and the period from emergence to last oviposition 16.4 days. The average number of eggs deposited was 14.65.

TABLE 41.—*Oviposition by 20 females of the sixth brood of the European red mite, Yakima, Wash., 1924*

Days	Number of days—			Number of eggs deposited
	Before oviposition	Of oviposition	From emergence to last oviposition	
Total	58	290	328	293
Average	2.9	14.5	16.4	14.65
Maximum	9	25	26	50
Minimum	1	8	11	2

LENGTH OF LIFE OF ADULTS

Males of the sixth brood lived an average of 12.56 days and females 21.63 days, as Table 42 shows.

TABLE 42.—*Length of life of adults of the sixth brood of the European red mite, Yakima, Wash., 1924*

		Male	Female
Number of individuals		9	24
Total	days	113	519
Average length of life	do	12.56	21.63
Maximum length of life	do	24	39
Minimum length of life	do	4	9

LIFE CYCLE OF THE SIXTH GENERATION

Tables 43 and 44 give the life cycles of 25 males and 32 females, respectively. The average life cycle of the males was 17.52 days, and that of the females 19.03 days, which, with a preoviposition period of 2.9 days, makes an average complete life cycle of 21.93 days for the females.

TABLE 43.—*Life cycle of 25 males of the sixth brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	July 17	July 26	July 29	July 31	Aug. 2	9	3	2	2	16
2	July 20	July 28	July 31	Aug. 2	Aug. 4	8	3	2	2	15
3	July 23	July 31	Aug. 2	Aug. 4	Aug. 7	8	2	2	3	15
4	do	Aug. 1	Aug. 3	Aug. 6	Aug. 8	9	2	3	2	16
5	July 24	July 31	Aug. 2	Aug. 5	Aug. 7	7	2	3	2	14
6	July 25	Aug. 2	Aug. 4	Aug. 6	Aug. 8	8	2	2	2	14
7	July 26	Aug. 5	Aug. 7	Aug. 9	Aug. 11	10	2	2	2	16
8	July 31	Aug. 9	Aug. 11	Aug. 13	Aug. 15	9	2	2	2	15
9	Aug. 1	do	do	do	do	8	2	2	2	14
10	Aug. 4	Aug. 12	Aug. 15	Aug. 17	Aug. 21	8	3	2	4	17
11	Aug. 11	Aug. 20	Aug. 23	Aug. 25	Aug. 27	9	3	2	2	16
12	do	Aug. 22	Aug. 25	Aug. 27	Aug. 29	11	3	2	2	18
13	Aug. 12	Aug. 20	Aug. 24	Aug. 29	Sept. 2	8	4	5	4	21
14	do	Aug. 22	do	Aug. 26	Aug. 28	10	2	2	2	16
15	do	do	Aug. 25	Aug. 29	Sept. 2	10	3	4	4	21
16	Aug. 22	Aug. 30	Sept. 3	Sept. 5	Sept. 7	8	4	2	2	16
17	Aug. 23	Sept. 1	Sept. 4	Sept. 6	Sept. 8	9	3	2	2	16
18	do	do	Sept. 5	Sept. 9	Sept. 14	9	4	4	5	22
19	do	Sept. 2	do	Sept. 7	Sept. 12	10	3	2	5	20
20	Aug. 24	do	do	Sept. 8	Sept. 14	9	3	3	6	21
21	do	Sept. 3	do	Sept. 9	Sept. 15	10	2	4	6	22
22	Aug. 25	do	do	Sept. 7	Sept. 13	9	2	2	6	19
23	do	do	Sept. 6	Sept. 8	Sept. 11	9	3	2	3	17
24	do	Sept. 4	Sept. 7	Sept. 13	Sept. 16	10	3	6	3	22
25	Aug. 28	Sept. 7	Sept. 10	Sept. 14	do	10	3	4	2	19
Total						225	68	68	77	438
Average						9	2.72	2.72	3.08	17.52
Maximum						11	4	6	6	22
Minimum						7	2	2	2	14

TABLE 44.—*Life cycle of 32 females of the sixth brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	July 25	Aug. 2	Aug. 4	Aug. 7	Aug. 9	8	2	3	2	15
2	July 28	Aug. 5	Aug. 8	Aug. 10	Aug. 12	8	3	2	2	15
3	July 30	Aug. 8	Aug. 10	Aug. 12	Aug. 14	9	2	2	2	15
4	Aug. 1	Aug. 9	Aug. 11	Aug. 13	Aug. 15	8	2	2	2	14
5	Aug. 2	Aug. 11	Aug. 13	Aug. 15	Aug. 19	9	2	2	4	17
6	Aug. 5	Aug. 12	Aug. 15	Aug. 19	Aug. 23	7	3	4	4	18
7	Aug. 6	Aug. 13	do	do	do	7	2	4	4	17
8	do	do	Aug. 16	Aug. 20	Aug. 24	7	3	4	4	18
9	do	do	do	Aug. 21	do	7	3	5	3	18
10	do	do	do	Aug. 22	Aug. 25	7	3	6	3	19
11	do	Aug. 14	Aug. 17	do	Aug. 24	8	3	5	2	18
12	Aug. 9	Aug. 16	Aug. 20	Aug. 25	Aug. 28	7	4	5	3	19
13	do	do	Aug. 22	do	do	7	6	3	3	19
14	Aug. 10	Aug. 19	do	do	Aug. 27	9	3	3	2	17
15	do	Aug. 20	Aug. 24	Aug. 26	Aug. 29	10	4	2	3	19
16	Aug. 12	do	do	Aug. 27	Aug. 30	8	4	3	3	18
17	do	Aug. 22	Aug. 25	do	Aug. 29	10	3	2	2	17
18	Aug. 13	Aug. 23	do	Aug. 28	Aug. 31	10	2	3	3	18
19	Aug. 14	Aug. 24	Aug. 27	Aug. 30	Sept. 3	10	3	3	4	20
20	do	do	Aug. 28	Aug. 31	do	10	4	3	3	20
21	Aug. 16	Aug. 26	Aug. 29	Sept. 3	Sept. 5	10	3	5	2	20
22	Aug. 17	Aug. 27	do	Sept. 2	do	10	2	4	3	19
23	Aug. 20	Aug. 29	Sept. 1	Sept. 3	Sept. 7	9	3	2	4	18
24	Aug. 21	Aug. 28	do	Sept. 4	Sept. 6	7	4	3	2	16
25	do	Aug. 29	Sept. 3	Sept. 5	Sept. 8	8	5	2	3	18
26	do	Aug. 30	Sept. 2	Sept. 6	Sept. 10	9	3	4	4	20
27	Aug. 22	do	Sept. 3	Sept. 5	Sept. 7	8	4	2	2	16
28	do	Sept. 5	Sept. 8	Sept. 12	Sept. 16	14	3	4	4	25
29	Aug. 24	Sept. 3	Sept. 6	Sept. 9	Sept. 14	10	3	3	5	21
30	Aug. 25	Sept. 4	Sept. 7	Sept. 15	Sept. 22	10	3	8	7	28
31	Aug. 26	Sept. 5	Sept. 8	Sept. 11	Sept. 27	10	3	3	16	32
32	Sept. 1	Sept. 10	Sept. 14	Sept. 17	Sept. 26	9	4	3	9	25
Total						280	101	109	119	609
Average						8.75	3.16	3.41	3.72	19.03
Maximum						14	6	8	16	32
Minimum						7	2	2	2	14

THE SEVENTH GENERATION

EGGS OF THE SEVENTH BROOD

TIME OF OVIPOSITION

Figure 15 shows that seventh-brood eggs were deposited from August 9 to October 11. There was no very definite maximum deposition, though more eggs were deposited from September 1 to 8 than at any other time.

LENGTH OF INCUBATION

The incubation period of 279 seventh-brood eggs averaged 11.05 days, the maximum being 33 and the minimum 7, as is shown in Table 45.

TABLE 45.—*Length of incubation period of 279 eggs of the seventh brood of the European red mite, Yakima, Wash., 1924*

Length of period	Number of eggs	Length of period	Number of eggs
7 days	10	17 days	4
8 days	30	18 days	5
9 days	53	19 days	9
10 days	72	20 days	2
11 days	41	21 days	1
12 days	18	22 days	1
13 days	10	23 days	1
14 days	8	33 days	1
15 days	10	Average, 11.05 days.	
16 days	3		

TIME OF HATCHING

Seventh-brood eggs were hatching from August 17 to October 14, as is shown in Figure 15.

IMMATURE STAGES OF THE SEVENTH BROOD

LENGTH OF THE LARVAL PERIOD

In Table 46 it is seen that the larval period of the seventh brood averaged 4.71 days, the maximum being 17 and the minimum 2.

TABLE 46.—*Length of larval period of European red mites of the seventh brood, Yakima, Wash., 1924*

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	26	58	2.23	3	1	47	1.81	4	1	105	4.04	6	2
Female	10	23	2.30	4	1	9	.90	1	0	32	3.20	5	2
Both sexes	58	157	2.71	10	1	116	2.00	7	1	273	4.71	17	2

LENGTH OF THE NYMPHAL PERIOD

The nymphal period of the seventh brood averaged 9.09 days, the maximum being 16 and the minimum 4, as shown in Table 47.

TABLE 47.—*Length of nymphal period of European red mites of the seventh brood, Yakima, Wash., 1924*

PROTONYMPH

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Males	24	52	2.17	4	1	54	2.25	5	1	106	4.42	8	2
Females	10	16	1.60	3	1	10	1.00	1	1	26	2.60	4	2
Both sexes	34	68	2.00	4	1	64	1.88	5	1	132	3.88	8	2

DEUTONYMPH

Males	24	74	3.08	5	1	67	2.79	5	1	141	5.88	10	2
Females	10	20	2.00	5	1	16	1.60	3	1	36	3.60	8	2
Both sexes	34	94	2.76	5	1	83	2.44	5	1	177	5.21	10	2

COMBINED TOTAL

Males	24									247	10.29	16	6
Females	10									62	6.20	11	4
Both sexes	34									309	9.09	16	4

ADULTS OF THE SEVENTH BROOD

OVIPOSITION

Seventh-brood females deposited an average of only 9 eggs, as it was late in the season. Table 48 shows that there was an average preoviposition period of 3.2 days, an average oviposition period of 10.4 days, and an average of 12.6 days from emergence to last oviposition.

TABLE 48.—*Oviposition by five females of the seventh brood of the European red mite, Yakima, Wash., 1924*

Days	Number of days—			Number of eggs deposited
	Before oviposition	Of oviposition	From emergence to last oviposition	
Total	16	52	63	45
Average	3.2	10.4	12.6	9
Maximum	5	19	21	24
Minimum	2	1	3	1

LENGTH OF LIFE OF ADULTS

Males lived an average of 13.59 days and females an average of 20 days, as shown in Table 49.

TABLE 49.—*Length of life of adults of the seventh brood of the European red mite Yakima, Wash., 1924*

	Male	Female
Number of individuals	17	5
Total—days	231	100
Average length of life—do	13.59	20
Maximum length of life—do	34	28
Minimum length of life—do	3	15

LIFE CYCLE OF THE SEVENTH GENERATION

Tables 50 and 51 give the life cycles of 24 males and 10 females, respectively. The average life cycle of the males was 24.35 days, and that of the females was 18.3 days. This difference is due to the fact that most of the males were reared later in the season and consequently in colder weather than the females. To the female life cycle should be added the preoviposition period of 3.2 days, giving a complete life cycle of 21.5 days.

TABLE 50.—*Life cycle of 24 males of the seventh brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	Aug. 15	Aug. 25	Aug. 27	Aug. 30	Sept. 3	10	2	3	4	19
2	Aug. 27	Sept. 5	Sept. 7	Sept. 10	Sept. 14	9	2	3	4	18
3	do	Sept. 6	Sept. 10	Sept. 13	Sept. 16	10	4	3	3	20
4	Aug. 28	do	do	Sept. 14	Sept. 17	9	4	4	3	20
5	do	Sept. 7	do	do	Sept. 16	10	3	4	2	19
6	do	do	Sept. 12	Sept. 15	Sept. 18	10	5	3	3	21
7		do	do	do	do		5	3	3	
8	Aug. 29	Sept. 8	Sept. 13	do	Sept. 20	10	5	2	5	22
9	do	Sept. 6	Sept. 10	Sept. 14	Sept. 18	8	4	4	4	20
10	do	Sept. 9	Sept. 14	Sept. 16	Sept. 23	11	5	2	7	25
11	do	Sept. 10	do	Sept. 17	do	12	4	3	6	25
12	Aug. 31	Sept. 11	Sept. 15	do	Sept. 25	11	4	2	8	25
13	do	do	do	Sept. 20	Sept. 30	11	4	5	10	30
14	Sept. 1	Sept. 10	Sept. 13	Sept. 15	Sept. 20	9	3	2	5	19
15	do	do	Sept. 15	Sept. 20	Sept. 28	9	5	5	8	27
16	do	Sept. 11	do	do	do	10	4	5	8	27
17	Sept. 2	Sept. 10	Sept. 14	Sept. 17	Sept. 23	8	4	3	6	21
18	Sept. 3	Sept. 13	Sept. 16	Sept. 22	Sept. 29	10	3	6	7	26
19	do	do	do	do	Sept. 30	10	3	6	8	27
20	do	do	do	Sept. 23	Oct. 2	10	3	7	9	29
21	Sept. 4	Sept. 14	Sept. 18	Sept. 26	Oct. 4	10	4	8	8	30
22	do	Sept. 15	Sept. 20	Sept. 27	Oct. 2	11	5	7	5	28
23	do	do	do	Sept. 28	Oct. 6	11	5	8	8	32
24	Sept. 6	do	Sept. 21	Sept. 29	do	9	6	8	7	30
Total						[1] 228	96	106	141	[1] 560
Average						9.91	4	4.42	5.88	24.35
Maximum						12	6	8	10	32
Minimum						8	2	2	2	18

[1] 23 individuals.

TABLE 51.—*Life cycle of 10 females of the seventh brood of the European red mite, Yakima, Wash., 1924*

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	Aug. 11	Aug. 20	Aug. 23	Aug. 25	Aug. 27	9	3	2	2	16
2	Aug. 13	Aug. 22	Aug. 24	Aug. 26	Aug. 29	9	2	2	3	16
3	Aug. 19	Aug. 28	Sept. 2	Sept. 5	Sept. 7	9	5	3	2	19
4	Aug. 21	Aug. 30	do	do	do	9	3	3	2	17
5	Aug. 22	Aug. 29	Aug. 31	Sept. 4	Sept. 6	7	2	4	2	15
6	do	Aug. 30	Sept. 3	Sept. 6	Sept. 8	8	4	3	2	17
7	Aug. 23	Sept. 1	Sept. 4	do	Sept. 9	9	3	2	3	17
8	do	Sept. 2	Sept. 5	Sept. 7	Sept. 12	10	3	2	5	20
9	Aug. 25	Sept. 3	Sept. 6	Sept. 8	Sept. 15	9	3	2	7	21
10	Aug. 31	Sept. 10	Sept. 14	Sept. 17	Sept. 25	10	4	3	8	25
Total						89	32	26	36	183
Average						8.9	3.2	2.6	3.6	18.3
Maximum						10	5	4	8	25
Minimum						7	2	2	2	15

THE EIGHTH GENERATION

EGGS OF THE EIGHTH BROOD

TIME OF OVIPOSITION

Eighth-brood eggs were deposited from August 28 to October 6, the maximum being deposited on September 5. This is shown in Figure 15.

LENGTH OF INCUBATION

The incubation period of 58 eggs averaged 14 days, the maximum being 29 and the minimum 7, as is shown in Table 52.

TABLE 52.—*Length of incubation period of 58 eggs of the eighth brood of the European red mite, Yakima, Wash., 1924*

Length of period	Number of eggs	Length of period	Number of eggs
7 days	2	19 days	3
8 days	0	20 days	2
9 days	5	21 days	1
10 days	12	22 days	2
11 days	10	23 days	1
12 days	3	24 days	0
13 days	1	25 days	1
14 days	3	26 days	0
15 days	2	27 days	0
16 days	3	28 days	1
17 days	3	29 days	1
18 days	2	Average, 14 days.	

TIME OF HATCHING

Figure 15 shows that the eggs hatched from September 8 to October 15.

IMMATURE STAGES OF THE EIGHTH BROOD

LENGTH OF THE LARVAL PERIOD

Table 53 gives the average length of the larval period as 6 days, the maximum as 13, and the minimum as 3.

TABLE 53.—*Length of larval period of 13 European red mites of the eighth brood, Yakima, Wash., 1924*

	Total	Average	Maximum	Minimum
	Days	*Days*	*Days*	*Days*
Feeding	47	3.62	9	2
Quiescent	31	2.38	4	1
Total	78	6.00	13	3

LENGTH OF THE NYMPHAL PERIOD

The nymphal period averaged 11 days; the maximum was 14, and the minimum was 9, as Table 54 shows.

TABLE 54.—*Length of nymphal period of European red mites of the eighth brood, Yakima, Wash., 1924*

PROTONYMPH

Sex	Number	Number of days											
		Feeding				Quiescent				Total			
		Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Male	1	2				1				3			
Female	3	7	2.33	4	1	5	1.67	3	1	12	4.00	7	2
Both sexes	4	9	2.25	4	1	6	1.50	3	1	15	3.75	7	2

DEUTONYMPH

Male	1	4				2				6			
Female	3	11	3.67	5	3	12	4.00	4	4	23	7.67	9	7
Both sexes	4	15	3.75	5	3	14	3.50	4	2	29	7.25	9	6

COMBINED TOTAL

Male	1									9			
Female	3									35	11.67	14	9
Both sexes	4									44	11.00	14	9

ADULTS OF THE EIGHTH BROOD

Although four eighth-brood adults were secured, cold weather and the consequent dropping of the foliage made it impossible to obtain records of their oviposition or longevity. One female lived 22 days before the leaf dropped, depositing a single egg on the tenth day. Two other females lived 14 and 19 days, respectively, without depositing any eggs.

LIFE CYCLE OF THE EIGHTH GENERATION

The life cycle of the only male reared to maturity was 22 days. The three females had an average life cycle of 26.33 days, as shown in Table 55.

TABLE 55.—*Life cycle of one male and three females of the European red mite of the eighth brood, Yakima, Wash., 1924*

MALE

No.	Date of—			Date of nymphal molts		Length of stages in days				
	Egg deposition	Hatching	Larval molt	Protonymph	Deutonymph	Egg	Larval	Protonymph	Deutonymph	Total
1	Sept. 1	Sept. 10	Sept. 14	Sept. 17	Sept. 23	9	4	3	6	22

FEMALE

1	Aug. 29	Sept. 8	Sept. 14	Sept. 16	Sept. 23	10	6	2	7	25
2	Aug. 30	do	do	Sept. 17	Sept. 26	9	6	3	9	27
3	Sept. 4	Sept. 14	Sept. 17	Sept. 24	Oct. 1	10	3	7	7	27
Total						29	15	12	23	79
Average						9.67	5	4	7.67	26.33
Maximum						10	6	7	9	27
Minimum						9	3	2	7	25

SUMMARY OF LIFE-HISTORY PHASES

The life-history studies made in 1923 were not complete, but Table 56 presents a summary of the more important phases, as far as it is possible to give it. In Table 57 is given a similar summary for 1924. It will be seen that there is considerable variation in the average length of a given phase in the different broods. This is chiefly due to variations in the temperature. The average of these phases for all broods in the two years agrees very well. In these tables the average length of the complete life cycle does not agree exactly with the sum of the averages for the various phases of that life cycle, for the reason that the life-cycle averages are figured from the individuals that completed their life cycle, while the other figures include many additional individuals that did not complete the life cycle.

TABLE 56.—*Summary of the phases in the life of the European red mite, Yakima, Wash., 1923*

Generation	Average length of stages			Preoviposition period	Average length of complete life cycle (including preoviposition period)	Average length of oviposition period	Average number of eggs per female	Average length of life of adults	
	Incubation	Larval	Nymphal					Male	Female
	Days	*Days*	*Days*	*Days*	*Days*	*Days*		*Days*	*Days*
First		6.91	5.81	2.24	[1] 14.47	15.13	25.57		16.56
Second	13.13	3.52	6.46	2.22	26.00	12.25	36.00		14.50
Third	9.89	2.79	4.67	1.66	19.43	11.95	25.75	8.00	14.89
Fourth	7.71	2.44	3.98	1.92	16.33	7.20	17.00		14.00
Fifth	8.47	*2.56	4.10	2.14	17.86				
Sixth	7.49	2.62	4.45	2.33	17.30	8.38	14.75	9.33	15.25
Seventh	10.10	3.51	8.29	6.57	29.39	7.50			17.40
Eighth	19.00								
Average	10.83	3.48	5.39	2.73	21.05	10.40	23.81		15.43

[1] This does not include the incubation period and is not considered in figuring the seasonal average.

TABLE 57.—*Summary of the phases in the life of the European red mite, Yakima, Wash., 1924*

Generation	Average length of stages			Preoviposition period	Average length of complete life cycle (including preoviposition period)	Average length of oviposition period	Average number of eggs per female	Average length of life of adults	
	Incubation	Larval	Nymphal					Male	Female
	Days	*Days*	*Days*	*Days*	*Days*	*Days*		*Days*	*Days*
First		4.99	7.45	2.28	[1] 15.16	9.94	26.03	8.36	12.11
Second	8.29	2.58	4.63	1.68	17.22	15.24	34.51	15.29	17.00
Third	10.04	2.65	4.90	1.74	19.44	10.71	25.51	10.65	12.69
Fourth	8.33	2.65	4.81	2.12	17.67	8.76	15.68	11.18	11.91
Fifth	8.56	2.82	5.15	2.12	18.85	11.88	15.52	8.85	14.33
Sixth	9.23	3.11	6.76	2.90	21.93	14.50	14.65	12.56	21.63
Seventh	11.05	4.71	9.09	3.20	21.50	10.40	9.00	13.59	20.00
Eighth	14.00	6.00	11.00		[2] 26.33				
Average	9.93	3.69	6.72	2.29	20.42	11.63	20.13	11.50	15.67

[1] This does not include the incubation period and is not considered in figuring the seasonal average.
[2] This does not include the preoviposition period.

It may be said that there is an average incubation period of approximately 10 days, a larval period of 3.5 days, a nymphal period of 6 days, and a preoviposition period of 2.5 days, which would result in a complete life cycle of approximately 22 days. The individuals actually completing their life cycle in 1923 averaged 21.05 days, and those completing the life cycle in 1924 averaged 20.42 days.

The female mites oviposit for approximately 11 days, during which time they generally deposit from 20 to 24 eggs, or about 2 eggs per day. Individual records were obtained, however, of females that deposited 80 to 90 eggs. (See Tables 6 and 13.) The females live about 15.5 days and the males about 11.5 days on the average, although some individuals have been found to live as long as 39 and 34 days, respectively. (See Tables 42 and 49.)

MISCELLANEOUS STUDIES

PARTHENOGENESIS

The females of the European red mite can reproduce parthenogenetically, although it is probable that under natural conditions parthenogenesis seldom occurs except where the mites are scarce. The eggs deposited by unfertilized females produce only males. Those deposited by fertilized females produce both males and females. Ross and Robinson (*27*) state that field counts showed only about 1 male to 10 females, and Hamilton (*15, p. 187*) concludes from this "that the fertilized eggs produce females and the unfertilized eggs males." While the latter part of this statement is true, the fertilized eggs produce mites of both sexes. Males and females are produced, whether the eggs have been fertilized by males descended from mated females or from unmated females. The writers kept a record in 1924 of the sex of mites produced from 368 eggs. There were 154 males, or 41.8 per cent, and 214 females, or 58.2. Theoretically, fertile eggs should produce males and females in equal numbers, and if a larger number of eggs had been recorded the numbers of males and females would probably have been more nearly equal. The

comparative numbers that may be found in the orchard will vary with the time the examination is made. The males mature sooner than the females, and do not live so long. Therefore an examination made when the mites of any given brood are beginning to mature would show a preponderance of males, while an examination made later would show more females. On May 2, 1923, 151 mites were examined. Only 42 of these had matured, this being only about two weeks after the winter eggs had started to hatch, and these consisted of 27 males and 15 females. On July 3, 1923, a similar examination showed 17 males and 37 females.

A study was made at Yakima, Wash., of the effect of parthenogenesis on the European red mite, including a comparison of the length of life of fertilized and unfertilized females, the comparative number of eggs deposited by these females, the incubation period, the percentage of eggs hatching, and the comparative length of life of males resulting from fertile and infertile eggs.

LENGTH OF LIFE OF FEMALES

In 1923, 30 fertilized females lived an average of 15.60 days, while 19 unfertilized females lived an average of 15.85 days. In 1924, 20 fertilized females lived an average of 17.05 days, while 19 unfertilized females lived an average of only 14.74 days. This would indicate that there is very little difference in the length of life of fertilized and unfertilized females, the latter probably not living quite so long as the former.

EGGS

Records were made in 1923 and in 1924 of the number of eggs deposited by fertilized and unfertilized females, and the number that hatched. Table 58 compares the eggs deposited by these females, the eggs being those deposited at the same time of the year, in order that other factors should be equal. The fertilized females averaged 29.02 eggs each, and the unfertilized females averaged only 27.17 eggs each, or 1.85 eggs less. Ross and Robinson (*27*) recorded an average of 38.6 eggs deposited by fertilized females and an average of 25 eggs by unfertilized females. The fertile eggs hatched better than the parthenogenetic eggs, an average of 85.32 per cent of the former hatching, and only 76.53 per cent of the latter.

TABLE 58.—*Comparison of parthenogenetic and fertile eggs of the European red mite, Yakima, Wash., 1923 and 1924*

Year	Parthenogenetic eggs					Fertile eggs				
	Females	Eggs deposited	Average per female	Eggs hatched		Females	Eggs deposited	Average per female	Eggs hatched	
	Number	*Number*	*Number*	*Number*	*Per ct.*	*Number*	*Number*	*Number*	*Number*	*Per ct.*
1923	21	496	23.62	367	73.99	30	756	25.20	634	83.86
1924	21	645	30.71	510	79.07	20	695	34.75	604	86.91
Average			27.17		76.53			29.02		85.32

In 1924 the incubation period of fertile and parthenogenetic eggs was compared. The average incubation period of 766 fertile eggs

was 10.45 days, whereas the average incubation period of 479 parthenogenetic eggs, deposited at the same time, was 10.57 days, the two average periods thus being approximately equal.

LENGTH OF LIFE OF MALES

Records of the length of life of 29 males from parthenogenetic eggs and 19 males from fertile eggs, living at the same time of the season, were compared, and it was found that the average length of life of the former was 13.8 days, and of the latter 13.2 days.

Parthenogenesis in the European red mite thus appears to shorten the life of the female slightly, to cause females to deposit fewer eggs, and to cause a smaller number of the eggs deposited to hatch. It does not appear to affect the length of life of the resulting males, however.

TIME OF EGG DEPOSITION

Records of the oviposition of females of the European red mite were made twice daily for a short time in May, 1923, the observations being made at approximately 9 a. m. and 5 p. m. Of 181 eggs laid during this time, 143, or nearly 80 per cent, were laid between 9 a. m. and 5 p. m. The average mean temperature during this interval was 71° F., whereas the average mean temperature during the interval from 5 p. m. to 9 a. m. was 57°. Another series of observations, made on the same dates, but at 10 a. m. and 5.30 p. m., showed that only about half the eggs were laid between these hours.

RATE OF OVIPOSITION

Since the average daily egg deposition of the female mites has a direct bearing on the rate of increase of the mites, data are given in Table 59 to show the rate of oviposition. Apparently the females of the earlier broods deposit more eggs per day than those of the later ones, the average number of eggs per female per day being 2.64, 2.37, 2.47, and 1.85 for the first four broods, respectively, and only 1.3, 1.3, and 1.29 for the fifth, sixth, and seventh broods. This difference in the rate is borne out by the figures for the average total number of eggs per female, which are given in Table 60. It will be seen there that the total number is much higher for the first three broods, at least, than for the later broods. This difference in the rate of oviposition can not be explained entirely by differences in the mean temperature, since the temperatures averaged higher during the time the fifth and sixth broods were ovipositing, for example, than during the oviposition period of the first and second broods. It is possible that extremely warm weather decreases the rate of oviposition. Also the more mature condition of the foliage may provide less suitable food for the mites, which would probably affect the rate of oviposition. There was an average daily oviposition per female of 1.89 eggs for all broods.

TABLE 59.—*Rate of oviposition by the European red mite, Yakima, Wash., 1924*

Number of eggs per day per female	Number of cases						
	First brood	Second brood	Third brood	Fourth brood	Fifth brood	Sixth brood	Seventh brood
0	19	45	27	19	71	50	11
1	102	160	89	82	154	119	14
2	67	164	92	87	69	49	6
3	63	96	109	50	34	21	5
4	56	79	69	11	7	9	2
5	30	36	25	3	2	2	
6	12	8	4				
7	4	5					
8	5	4			1		
9		2					
10	1	1					
11							
12		1					
Average	2.64	2.37	2.47	1.85	1.3	1.3	1.29
Average mean temperature (° F.)	66	65.4	69.1	71.4	70.8	67.5	65.3

Average number of eggs per day per female for all broods, 1.89.

TABLE 60.—*Average number of eggs deposited by the European red mite, Yakima Wash., 1924*

Brood	Average total number of eggs per female	Brood	Average total number of eggs per female
First	26.03	Fifth	15.52
Second	34.51	Sixth	14.65
Third	25.51	Seventh	9.00
Fourth	15.68	Average	20.13

PERCENTAGE OF EGGS HATCHING

Table 61 shows the percentage of eggs hatching for each brood in 1923 and 1924. The average for all broods in 1923 was 72.25 per cent and in 1924, 76.74 per cent.

TABLE 61.—*Number of summer eggs deposited and number and percentage hatched of the European red mite at Yakima, Wash., 1923 and 1924*

Brood	1923			1924		
	Eggs deposited	Eggs hatched		Eggs deposited	Eggs hatched	
	Number	*Number*	*Per cent*	*Number*	*Number*	*Per cent*
Second	833	676	81.15	1,120	955	85.27
Third	726	506	69.70	1,547	1,246	80.54
Fourth	848	641	75.59	1,152	745	64.67
Fifth	290	198	68.28	674	494	73.29
Sixth	300	254	84.67	662	587	88.67
Seventh	267	208	77.90	396	275	69.44
Eighth	33	16	48.48	77	58	75.32
Average of averages by broods			72.25			76.74

FEEDING AND QUIESCENT PERIODS

The quiescent periods of the immature stages of the European red mite are of particular interest because the quiescent individuals are more resistant to certain sprays than the active individuals. Table 62 gives the average feeding and quiescent periods for seven broods in 1924. This shows that the quiescent period averages nearly as long as the feeding period, the average total feeding period being 4.93 days and the average total quiescent period 4.54 days.

TABLE 62.—*Comparison of feeding and quiescent periods of immature stages of the European red mite, Yakima, Wash., 1924*

Brood	Larva		Protonymph		Deutonymph	
	Average feeding period	Average quiescent period	Average feeding period	Average quiescent period	Average feeding period	Average quiescent period
	Days	*Days*	*Days*	*Days*	*Days*	*Days*
First	2.72	2.27	1.52	1.73	1.66	2.55
Second	1.24	1.34	1.04	1.21	1.08	1.30
Third	1.33	1.32	1.17	1.16	1.21	1.36
Fourth	1.44	1.21	1.17	1.14	1.27	1.24
Fifth	1.66	1.16	1.43	1.07	1.42	1.23
Sixth	1.91	1.20	1.77	1.35	2.02	1.61
Seventh	2.71	2.00	2.00	1.88	2.76	2.44
Average of averages by broods	1.86	1.50	1.44	1.36	1.63	1.68

Average total feeding period, 4.93 days.
Average total quiescent period, 4.54 days.

NATURAL ENEMIES

The study of the European red mite in the Yakima Valley has shown that natural control through the agency of predacious enemies is of considerable importance. In each of the three years that these studies have been conducted, 1923, 1924, and 1925, there has been a general control by the several predatory enemies in most if not all of the orchards where the mites were present. This control takes place suddenly each season some time in August. The suddenness with which the mites disappear is one of the most remarkable features of this natural control. The last of July or early part of August 200 or 300 mites could be found on a leaf, while a few days later it was difficult in many cases to find more than an occasional one or two. This sudden decrease in the number of mites is doubtless due to the fact that the predacious enemies increase to such numbers and to such a stage in their development that their rate of consumption is far greater than the rate of increase of the mites. Up to that time the predators are so few that the rate of increase of the mite is in excess of the predators' food requirements. Unfortunately for the efficiency of control by these enemies, it comes after most of the injury to the foliage has been done. If natural control came in June instead of in August, artificial control would be unnecessary.

A great many different kinds of predacious enemies of *Paratetranychus pilosus*, and of other closely related mites, have been observed and recorded by various writers. Ross and Robinson (*27*) report *Stethorus punctum* Lec. in small numbers feeding on *P. pilosus* in Canada. The two-spotted lady beetle, *Adalia bipunctata* L., was also found apparently attacking this mite. These enemies,

however, did not appear to reduce the numbers of mites appreciably. Garman (*14*) records the following predators on *P. pilosus* in Connecticut: *Leptothrips mali* Fitch, *Scolothrips sexmaculatus* Pergande, *Holothrips* sp., *Triphleps insidiosus* Say, *Stethorus punctum* Lec., and the predacious mite *Seius pomi* Parrott. These he reports as most numerous in July and August, especially in 1922 and 1923. Hamilton, in Maryland (*15*), found only the coccinellid *Stethorus punctum*.

These are the only writers who have discussed the enemies of *P. pilosus* as such. However, a number of writers have reported predacious enemies of other mites and of *pilosus* under other names. It is quite probable that several of the enemies reported as preying upon *Tetranychus bimaculatus* Harvey (=*telarius* L.) and *T. mytilaspidis* Riley (=*citri* McGregor) are also found predatory on *pilosus*. Indeed, in many instances these three species have been more or less confused, especially *P. pilosus* and *T. mytilaspidis*, so that many of the predators reported on the citrus mite may prove common also on the red mite. This is particularly true where the host plants of the two species of mites intermingle or grow in the same general vicinity.

In the Yakima Valley the following predacious enemies of the European red mite have been found: A gamasid mite, *Seius* sp. (probably *S. pomi* Parrott); an anthocorid, *Triphleps insidiosus* Say; a coccinellid, *Stethorus picipes* Casey; and a species of thrips, *Scolothrips sexmaculatus* Pergande. In addition to these known predators it is very probable that a species of Hemerobius and one or two species of Chrysopa, as well as various coccinellids, will be found to be predacious on the red mite here, as they have been found elsewhere on related species and have been reported on *T. mytilaspidis* outside of the citrus regions.

SEIUS sp.

The predacious mite *Seius* sp. has been found occasionally in a number of orchards in the Yakima Valley. It has been taken feeding upon both summer and winter eggs of the red mite, but seems to prefer *T. telarius*. This gamasid destroys the mite eggs by piercing them with its mouth parts and sucking out the fluid contents. Occasionally it has been observed attacking and devouring red mites in the earlier larval and nymphal stages, but apparently it never attacks adults. It has been found as early in the spring as March 6, when it was feeding upon the winter eggs of both *Bryobia praetiosa* Koch and *P. pilosus*.

The eggs of *Seius* sp. were not observed, but the nymphs and adults were noted. (Fig. 16.) There is little apparent difference between the nymphs and adults except in size. The adult has the characteristic gamasid appearance and is figured by Ewing (*10*). (Fig. 17.)

In 1906 Parrott (*24*) described a species of Seius as *S. pomi*, which is probably the species present in the Yakima Valley. In 1912 Quayle (*25*) reported a gamasid as predatory on *T. mytilaspidis* in California. Ewing (*10*) discussed *S. pomi* in 1914 and described the various stages. He reported it as one of the most efficient natural enemies of *T. telarius* in Oregon, and as found also feeding upon the citrus mite *T. mytilaspidis*. It is probable that it was the European red mite that he had under observation in Oregon.

SCOLOTHRIPS SEXMACULATUS Pergande

A thrips, *Scolothrips sexmaculatus* Pergande (figs. 18 and 19), was observed in Wenatchee, Wash., in 1916, apparently feeding upon the European red mite. It has been found since then in both the Wenatchee and the Yakima Valleys. During the studies of *P. pilosus* from 1923 to 1925 this thrips was found many times feeding upon the eggs of the mite. Throughout its larval and adult stages it consumes great numbers of mites in all stages. It seems to prefer the eggs for its food, but sometimes it devours some of the quiescent larvae, nymphs, and rarely a few of the active forms. One thrips, in its last nymphal stage, consumed 7 eggs of *pilosus* in 30 minutes. Another, also in its last nymphal stage, consumed 5 eggs in 17 minutes. Still another consumed 55 eggs, at least 34 larvae, 7 nymphs, and possibly a half dozen adults, in 3 days.

The thrips attacks its prey, whether an egg or a mite, by puncturing the prey with its mouth parts. When it has sucked out most of the

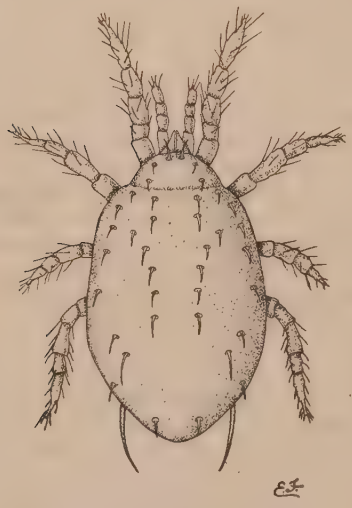


FIGURE 16.—Adult of *Seius* sp. × 100

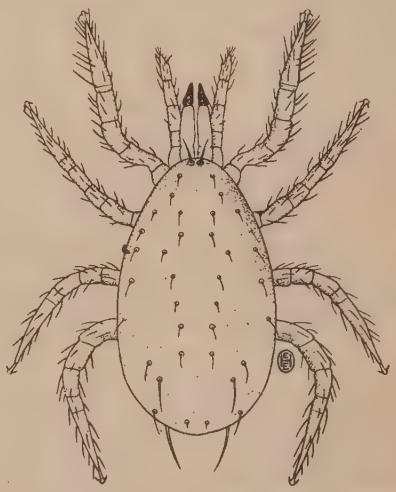


FIGURE 17.—Adult of *Seius pomi*. × 60. (Ewing)

fluid contents of a mite it rolls the mite over with its fore legs and again inserts its mouth parts, sucking out the remainder of the liquid contents. Sometimes it makes several punctures before it completes feeding upon a mite. When it attacks eggs, however, it usually sucks them dry through a single puncture.

Garman (*14*) states that only one or two thrips to a leaf are necessary to keep the red mite under control. Quayle (*25*) reported this thrips as feeding upon *Tetranychus mytilaspidis* in California. Ewing (*10*) reported it as present in Oregon but stated that it probably played but little part in helping to control the common red spider, *T. telarius*, in that State.

TRIPHLEPS INSIDIOSUS Say

One of the commonest predators of the European red mite is the anthocorid *Triphleps insidiosus* Say. (Figs. 20, 21, and 22.) This bug is often found feeding in its nymphal and adult stages upon all

stages of the mite. From its earliest nymphal stage until the adult dies its principal food apparently consists of the eggs, larvae, nymphs, and adults of the mites. It consumes such numbers of these mites (almost daily throughout its life) that it must be of considerable importance in checking their increase. The eggs of this anthocorid were not observed. All other stages were noted, and in all of these stages it was observed to feed upon great numbers of mites and mite eggs. One of the adults killed and devoured 12 mites in the half hour it was under observation. During this time it also attempted to capture a few others but missed catching them.

It kills its prey by coming upon it suddenly and thrusting its beak into the mite. (Fig. 21.) It usually retains its first hold, sucking out the fluid contents of the mite's body. Sometimes, however, it changes its hold and inserts its beak into a more suitable part of the anatomy. It requires from 30 to 60 seconds to suck out the contents of an adult female mite but only 10 to 20 seconds to extract the contents of an adult male or a nymph. One bug, captured while in its nymphal stage September 17, molted at noon on September 22. At 11 a. m. the next day it was given mites to eat. It immediately pounced upon an adult female mite, sucked out part of the fluid contents, and then left it. Immediately afterward it captured another female and treated it similarly. The next female captured was sucked entirely dry before it was left. The next day the empty, shriveled skins of 45 mites were found with the bug.

FIGURE 18.—Larvae (*a*) of *Scolothrips sexmaculatus* and empty eggshells (*b*) of the European red mite. × 15

Like the other predators of the red mite at Yakima, Wash., this insect does not appear very early in the season. The earliest record of it there is on June 4, but it does not seem to become common until late July or early August. It has been found as late as September 11, when it was feeding upon the winter eggs of the mite.

McGregor (*19*) reported this insect as a common enemy of *T. bimaculatus* (=*telarius*) on cotton in the South. There it had an average daily consumption of 33 individuals per nymph and of 28.88

individuals per adult. Quayle (*25*) and Ewing (*10*) have reported this predator from California and Oregon, respectively, and Ross and Robinson (*27*) have reported it from Canada. Garman (*14*) mentions it as an effective enemy of *P. pilosus* in Connecticut.

DESCRIPTION OF TRIPHLEPS INSIDIOSUS

The eggs were not observed.

NYMPH

The nymphs (figs. 20 and 21) range from about 1 millimeter to nearly 4 millimeters in length, according to the nymphal stage they are in. They are dark reddish brown, except the wing pads, which are hyaline. Abdominal segments show through the tips of the wing pads, and later through the fully developed wings. The wing pads are conspicuous on the thorax in the nymphal stages. The beak is prominent and about one-half the length of the body.

FIGURE 19.—Adult of *Scolothrips sexmaculatus*. × 15

ADULT

The adult (fig. 22) is about 2 to 3 millimeters long, and black, except for the hyaline wings. The wings are about one-third as broad as long. The adult resembles the last nymphal stage except for the addition of fully formed wings and a reduction in the size of the abdomen.

STETHORUS PICIPES Casey

Perhaps the most important enemy of the red mite in the Yakima Valley is the coccinellid beetle, *Stethorus picipes* Casey. (Fig. 23.) It has been found in considerable numbers in many orchards in the Pacific Northwest. In some orchards it is much more abundant than in others, and while it has not been uncommon to find as many as three or four to a leaf on many of the leaves on a given tree, in many other orchards it is almost impossible to find a single individual. The adults are active flyers in so far as the ability to fly suddenly for a short distance is concerned. But it is not known how far they are able to fly and thereby distribute themselves about over an orchard or from tree to tree.

Little is known about the life history of this coccinellid. It probably hibernates during the winter months in the rubbish beneath the trees in the orchards. Just when it emerges from hibernation in the spring is not known, but it is not until midsummer, late July or early

August, that it becomes noticeable in the orchards. From late July to October it can be found in all stages in the orchard, but after early September it is difficult to find any but adults.

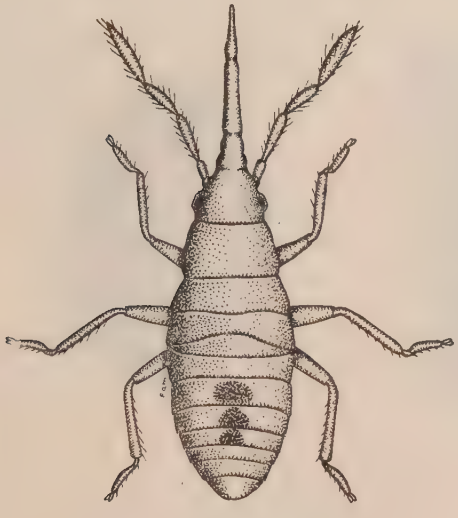


FIGURE 20.—Young nymph of *Triphleps insidiosus*. × 70. (McGregor)

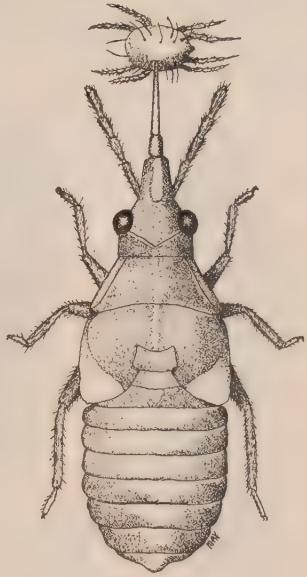


FIGURE 21.—Last-instar nymph of *Triphleps insidiosus*. × 25

Table 63 shows the length of incubation, the larval stage, the pupal stage, and the life cycle (except the preoviposition period) of *S. picipes*. The incubation period for the eggs is apparently about 6 to 10 days, the average being 7.29 days. The larval stage is from 12 to 18 days, the average being 14.29 days. The pupal stage is from 5 to 9

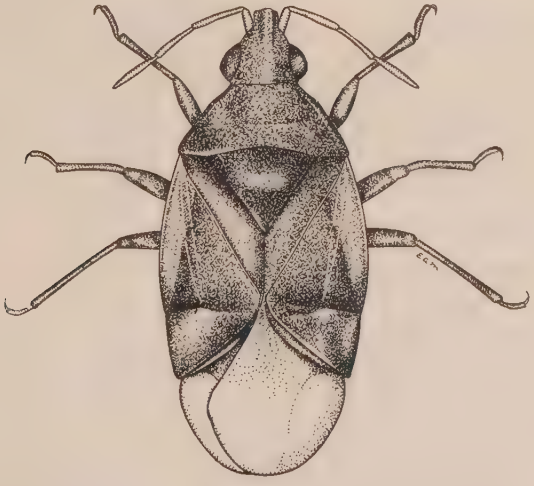


FIGURE 22.—Adult of *Triphleps insidiosus*. × 20. (McGregor)

days, or an average of 7.29 days. The life cycle is from 24 to 35 days, averaging 28.86 days. Allowing a little over a day for the preoviposition period, the average life cycle would be about 30 days. It is therefore obvious that since the beetles are present in the orchard from July to October, inclusive, there is ample time for several broods during the season.

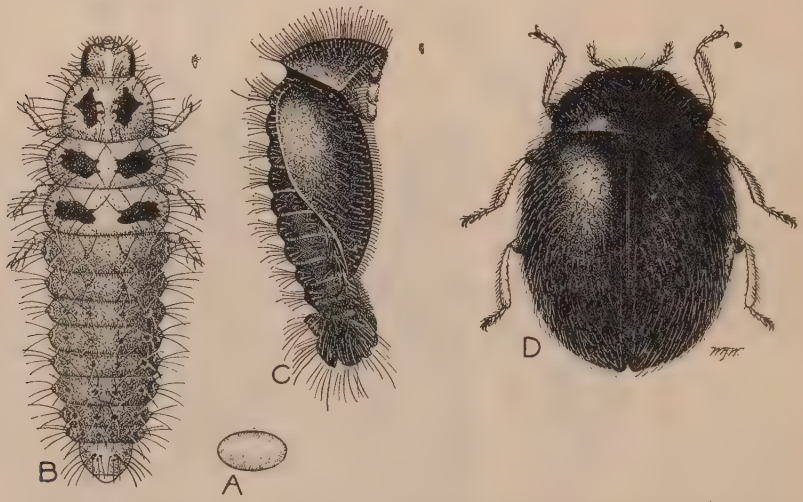


FIGURE 23.—*Stethorus picipes*, an enemy of the European red mite: A, Egg; B, larva; C, pupa; D, adult. × 35. (McGregor)

TABLE 63.—*Life cycle of Stethorus picipes, Yakima, Wash., 1923*

Date of deposition of eggs	Date of hatching	Number of days of incubation	Date of first molt	Number of days of first instar	Date of second molt	Number of days of second instar
July 31	Aug. 6	6	Aug. 10	4	Aug. 12	2
Aug. 3	Aug. 10	7	Aug. 14	4	Aug. 16	2
Aug. 25	Sept. 2	8	Sept. 7	5	Sept. 10	3
Do	Sept. 4	10	Sept. 10	6	Sept. 13	3
Aug. 26	Sept. 2	7	Sept. 8	6	Sept. 11	3
Aug. 29	Sept. 4	6	Sept. 9	5	Sept. 12	3
Do	Sept. 5	7	Sept. 10	5	do	2
Average		7.29		5		2.57
Maximum		10		6		3
Minimum		6		4		2

Date of deposition of eggs	Date of third molt	Number of days of third instar	Date of pupation	Number of days of fourth instar	Total length of larval stage (days)	Date adult issued	Number of days of pupal stage	Total number of days from deposition of eggs to emergence of adults
July 31	Aug. 14	2	Aug. 19	5	13	Aug. 24	5	24
Aug. 3	Aug. 18	2	Aug. 22	4	12	Aug. 27	5	24
Aug. 25	Sept. 12	2	Sept. 17	5	15	Sept. 26	9	32
Do	Sept. 17	4	Sept. 22	5	18	Sept. 29	7	35
Aug. 26	Sept. 13	2	Sept. 17	4	15	Sept. 26	9	31
Aug. 29	Sept. 14	2	Sept. 18	4	14	do	8	28
Do	do	2	do	4	13	do	8	28
Average		2.29		4.43	14.29		7.29	28.86
Maximum		4		5	18		9	35
Minimum		2		4	12		5	24

The Stethorus feeds during the larval and adult stages upon all forms of the red mite—eggs (summer and winter), larvae, nymphs, and adults. Each coccinellid during its life consumes several hundred mites in the different stages. (Tables 64–67.) In both its larval and adult stages it seems to prefer the eggs. (Table 64.) Possibly this is because these are more numerous, much smaller (requiring a greater number for the same quantity of food), and stationary and easily obtained. Next to the eggs, they seem to prefer the larvae and then the nymphs. The quiescent nymphs are, of course, as easily obtained as the eggs. Table 64 shows the number of each form consumed by both larvae and adults.

TABLE 64.—*Number of European red mites consumed by Stethorus picipes in larval and adult stages, Yakima, Wash., 1923*

Date	Number of hours observed	Stage of predator	Number consumed					
			Eggs	Larvae	Nymphs	Adult females	Adult males	Total
Aug. 1	1½	Larva	0	8	3	1	0	12
Aug. 2	2	----do	3	0	1	1	0	5
Aug. 3	2	----do	9	2	0	0	0	11
Aug. 6	3	Adult	29	10	10	3	5	[1] 57
Aug. 7	1	----do	4	0	3	0	1	8
Aug. 25	2½	Larva	7	1	1	0	2	11
Total	12		52	21	18	5	8	104

[1] This adult beetle had been starved for 2½ days.

In Table 65 is shown the rate of consumption of all forms by larvae alone. Two larvae, which were observed throughout their larval stage, consumed 291 and 372 mites and eggs, respectively. Other larvae were observed only during certain instars, as indicated. It will be observed that the quiescent period of the molting larvae slowed down, but did not entirely prevent consumption of the mites. During the actual molting process, of course, no mites were eaten, but during the whole 24 hours including the molting process a few mites were always eaten. The exact number of hours passed in the quiescent stage was not observed. The larvae start feeding within a few minutes after they have cast their skins, but they do not appear to have a maximum appetite until several hours after or on the following day.

TABLE 65.—*Rate of consumption of European red mites by larvae of Stethorus picipes, Yakima, Wash., 1924*

Date hatched	Number of eggs and mites consumed															
	First day	Second day	Third day	Fourth day	Fifth day	Sixth day	Seventh day	Eighth day	Ninth day	Tenth day	Eleventh day	Twelfth day	Thirteenth day	Fourteenth day	Fifteenth day	Total
Aug. 6	7	10	25	5	25	8	32	10	18	34	45	60	12	-----	-----	291
Sept. 2	5	12	20	38	10	12	25	7	25	12	28	45	50	75	8	372
Sept. 2 [1]	2	10	15	18	10	-----	-----	-----	-----	-----	20	25	40	55	10	-----
(1)	-----	-----	-----	-----	-----	-----	-----	-----	-----	10	15	15	10	15	17	-----
(1)	-----	-----	-----	-----	-----	-----	-----	-----	-----	10	25	20	35	42	10	-----
(1)	-----	-----	-----	-----	-----	-----	-----	-----	-----	12	17	42	20	40	25	-----
(1)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	8	36	24	20	30	-----
(1)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	12	30	32	18	25	-----
(1)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	48	12	22	20	-----	-----
(1)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	35	10	17	12	-----	-----

[1] The first 2 individuals were observed from hatching to pupation. The third individual was observed during the first and fourth instars only, and the other individuals were observed only during their fourth instar.

In Table 66 is shown the number of adult mites consumed by given adult beetles during varying lengths of time. One adult ate 137 adult mites during its life. Five other adult beetles consumed a total of 370 adult mites in four days. One other adult beetle consumed 145 adult mites in 10 days. It is very probable that under natural conditions more mites than here indicated would be consumed. In both cases where single beetles were confined with adult mites the supply of mites was nearly always exhausted. In the other case, where the five beetles were fed together, a number of leaves were supplied with the adult mites. These leaves seemed to retard the beetles in their search for food. Both the beetles and the larvae seem to have difficulty in finding mites or eggs when these are scarce. When the number is reduced to a half dozen or so to a leaf they may not be able to find them.

TABLE 66.—*Consumption of adult European red mites by adult Stethorus picipes, Yakima, Wash., 1925*

Individual No.	Days observed	Mites consumed	Average per day
	Number	*Number*	*Number*
1	31	137	4.42
2, 3, 4, 5, 6	4	370	18.50
7	10	145	14.50

Table 67 shows the number of mites and mite eggs consumed by larvae of *S. picipes* per instar. Two individuals were observed throughout their larval life, one in its first and fourth instars, and seven others in their fourth instar only. The number of mites and mite eggs consumed increased with each instar, and in the fourth instar more mites and eggs were consumed than during all the preceding instars combined.

TABLE 67.—*Number of European red mites and mite eggs consumed per instar by larvae of Stethorus picipes, Yakima, Wash., 1923*

Instar	Number of mites and eggs consumed by individual No.—									
	1	2	3	4	5	6	7	8	9	10
First	42	32				55				
Second	30	47								
Third	40	75								
Fourth	179	218	82	142	156	160	118	117	102	74
Total	291	372								

The effect of temperature and sunlight upon the activities of these beetles is shown in Table 68. While this test was rather meager, it indicates that the beetles are inactive at lower temperatures and in the shade, and more active in higher temperatures and in the sunlight. Supplementing this information, it was observed in the orchards that when the weather was warm the beetles were more active than during cool weather. They were also more active on the sunny side of trees than upon the shady side.

TABLE 68.—*Effect of temperature upon the activities of Stethorus picipes, Yakima, Wash., 1925*

Date	Time of day observed	Temperature	Weather conditions	Activities of beetle
		°F.		
Aug. 24	4.45 p. m.	69	Cool, shade	Beetle quiet.[1]
Do.	4.50 p. m.	75	Cool, sunshine	Beetle very active.
Aug. 25	9.00 a. m.	[2] 65	Cool, shade	Beetle sluggish.
Aug. 28	9.30 a. m.	[3] 61	Cool, cloudy	Beetle quiet.
Aug. 30	10.30 a. m.	77	Bright, sunny	Beetle very active.

[1] This beetle was resting quietly underneath the webbing on a leaf in the insectary. It was taken outside into the bright sunlight, which, on account of the clouds, came and went every few minutes. As soon as it was taken into the sunlight it became active, hurried about, and captured and devoured a mite. When it was taken back into the shade it became quiet at once.
[2] 44° F. during the preceding night.
[3] 37° F. during the preceding night.

A peculiar feeding habit of larvae of *S. picipes* is the manner in which, when it has drained out most of the fluid contents of the mite's body, it commences a series of regurgitations, spewing the contents back and forth from its own body into that of its host. The skin of the mite, which upon being drained becomes shriveled and colorless, takes back its color and plumpness as the fluids pass into its body again, streaming into the remotest parts of its legs, feet, and abdomen. This regurgitation takes place over and over again in the same host. In one of the first instances observed the regurgitation was repeated 27 times. Often the pumping is repeated 15 or 20 times. This is especially true with adult female mites. In the case of young mites or males the regurgitation is repeated only a few times. This peculiar habit was observed in the larvae only; the adult beetle apparently feeds in the normal manner. The purpose of this pumping back and forth seems to be to rinse out thoroughly all available food from the host's body. When the predator is very hungry, as when it has had nothing to eat for some time, it does not take time to rinse out the host's body, but drops it when only a part of the contents has been consumed and hastens to another mite.

The adult beetle not only sucks but also devours the eggs and mites. It usually first sucks the eggs or mites nearly dry and finishes by eating the shell or skin as the case may be.

One reason the adult female mite is not attacked more frequently is because the stiff bristles on her back make an attack less easily accomplished. Often the predator has been seen attempting to grasp the female only to find itself thrust back by the hedge of stiff bristles on the female's dorsum. One reason the male mites are not attacked more frequently is because of their extreme agility. They are almost too active to be captured by the predators.

One adult of *S. picipes*, confined on a piece of apple with winter eggs only for food, consumed 465 eggs in 10 days from September 21 to 30, inclusive. This doubtless accounts for many of the empty eggshells on the fruit and twigs where presumably only winter eggs are deposited.

DESCRIPTION OF STETHORUS PICIPES

EGG

The egg (fig. 23, A) is small, cream yellow or white, oval in shape, and about 0.30 millimeter long.

LARVA

The larva (figs. 23, B; 24, *a*, *b;* 25, *a*) is dark ash gray in color, about 1.5 to 2 millimeters in length. Each segment of the thorax has a pair of irregular black spots on the dorsal surface. The head, thorax, and abdomen are covered with long hairs. Each of the nine segments of the abdomen, except the last, has six whorls of bristles.

PUPA

The pupa (figs. 23, C; 24, *c;* 25, *b*), when first molted, is reddish, then brown, and finally black. It is flattened and covered with fine hairs which, except those posteriorly, are knobbed at their tips. The hairs are longer at the anterior and posterior ends of the pupa. The pupa is attached to the leaf by its posterior extremity.

ADULT

The adult (figs. 23, D; 24, *e*, *f;* 25, *c*) is of the typical scymnid shape and a little over a millimeter in length, clothed with fine hairs. Several hours after emergence its color becomes black.

FIGURE 24.—Stages of *Stethorus picipes*: *a*, Third-stage larva; *b*, fourth-stage larva; *c*, pupa; *d*, empty pupal shells; *e*, recently emerged adult; *f*, old adult. × 5

This coccinellid has been reported by Essig (*5, p. 7, 8, 10*) as one of the predacious enemies of the clover or almond mite, *Bryobia pratensis* Garm. (=*praetiosa* Koch), the six-spotted mite (*Tetranychus telarius* L.), and the citrus mite (*Tetranychus mytilaspidis* Riley) in California. Quayle (*25, p. 511*) states that *S. picipes* Casey is the most important enemy of the red spider in the same State. These are, as far as known, the only published reports of this species.

In addition to the foregoing known predators on the European red mite, it is very probable that other insect enemies are present in the Yakima Valley in few or considerable numbers. Wherever aphids are present in injurious numbers several species of lady beetles and syrphus flies are usually found feeding upon them. It is probable that where aphids and red mites are found together these coccinellids and syrphids feed upon both.

As previously pointed out, Ross and Robinson (*27*) reported one of these coccinellids, *Adalia bipunctata* L., as apparently feeding upon the mite in Canada. This species has recently been reported for the first time as feeding upon young tree hoppers, *Stictocephala inermis* Fab., in the Yakima Valley, and it is likely that it is also predacious on the European red mite.

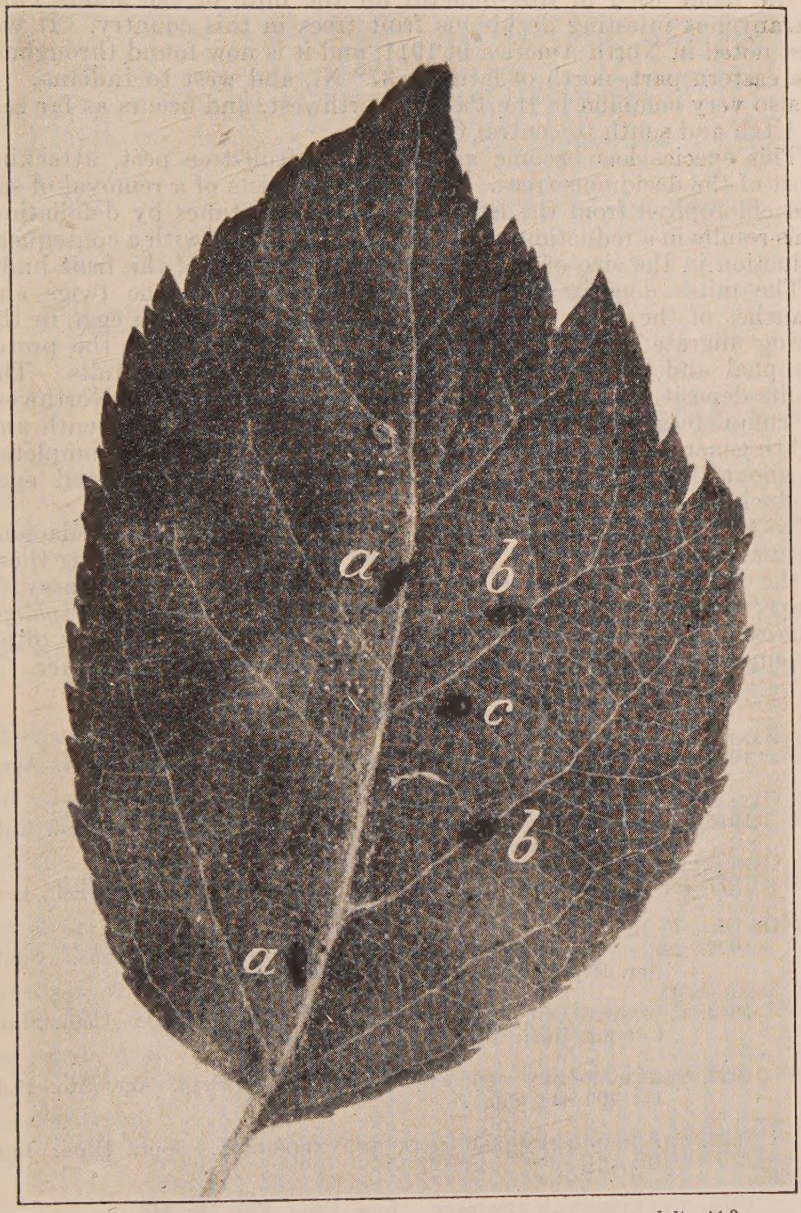


FIGURE 25.—*Stethorus picipes* on apple leaf: *a*, Larvae; *b*, pupae; *c*, adult. × 2

SUMMARY

The European red mite (*Paratetranychus pilosus* Can. and Fanz.) is the name used in this bulletin for the mite of the genus Paratetranychus infesting deciduous fruit trees in this country. It was first noted in North America in 1911, and it is now found throughout the eastern part, north of latitude 37° N., and west to Indiana. It is also very common in the Pacific Northwest, and occurs as far east as Utah and south to central California.

This species has become an important fruit-tree pest, attacking most of the deciduous trees. The injury consists of a removal of sap and chlorophyll from the leaves, followed sometimes by defoliation. This results in a reduction in the vitality of the tree, with a consequent reduction in the size of the crop and a weakening of the fruit buds.

The mites deposit red spherical winter eggs on the twigs and branches of the trees. The larvae hatching from these eggs in the spring migrate to the foliage to feed, and pass through the protonymphal and deutonymphal stages before becoming adults. The adults deposit summer eggs on the leaves. In the Pacific Northwest six complete generations occur in a season, and partial seventh and eighth generations. The life cycle of a single generation is completed in about 21 days. Parthenogenesis occurs, the unfertilized eggs producing males.

No true parasites of the mites have been observed, but predacious enemies play an important part in their control. Chief among these in the Pacific Northwest is a coccinellid, *Stethorus picipes* Casey; a thrips, *Scolothrips sexmaculatus* Pergande; an anthocorid, *Triphleps insidiosus* Say; and a gamasid mite, *Seius* sp. These enemies often accomplish almost complete control of the mites by late summer.

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